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CONTENTS

No. 1, September, 1930

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Page.

QUISUMBING, EDUARDO. Philippine Piperaceæ 1
Twenty-four plates and one hundred twenty-four text figures.

No. 2, October, 1930

[Issued August 27, 1930.]

MANALANG, C. Morphology and classification of the Philippine variety of Anopheles aconitus Donitz, 1902, and Anopheles minimus Theobald, 1901 247
One plate.

SCHÖBL, OTTO. Further experiments concerning immunologic reciprocity between yaws and syphilis 263

COCKERELL, T. D. A. The xylocopid or carpenter bees of the Philippine Islands 265

ALEXANDER, CHARLES P. New or little-known Tipulidæ from the Philippines (Diptera), VII 277
Two plates.

SANTOS, JOSÉ K. Leaf and bark structure of some cinnamon trees with special reference to the Philippine species.. 305
Twenty-one plates and twelve text figures.

No. 3, November, 1930

[Issued September 30, 1930.]

ROXAS, MANUEL L., and MANUEL VILLANO. Studies on the development of the sugar-cane plant in the Philippines. Root and shoot development of M-1900 367
Five plates and thirteen text figures.

MUNDO, SALVADOR DEL. The occlusion of lead and copper in nonferrous alloys by metastannic and metantimonic acids.. 403

SANTOS, IRENE DE, and AUGUSTUS P. WEST. Naphthol esters of chaulmoogric acid and chaulmoogryl naphthylamines.. 409

HARRIS, HALBERT M. Notes on Philippine Nabidæ, with a catalogue of the species of Gorpis (Hemiptera).. 415
One text figure.

MIYAO, ISAO. An inquiry into the so-called latent infection in yaws-vaccinated monkeys as a possible result of the test for immunity by intradermal inoculation with living yaws material.. 425

MIYAO, ISAO. Immunologic relation between three Philippine strains of yaws 429

MIYAO, ISAO. Is frambœsia tropica a nosologic entity?.. 433

HEGNER, ROBERT, and H. J. CHU. A survey of Protozoa parasitic in plants and animals of the Philippine Islands.. 451
Five plates.

No. 4, December, 1930

[Issued November 10, 1930.]

Page.

TALAVERA, FLORENCIO. Pearl fisheries of Sulu 483
Seven plates.

FAUSTINO, LEOPOLDO A. Notes on Mayon Volcano 501
One text figure.

ALEXANDER, CHARLES P. New or little-known Tipulidæ from eastern Asia (Diptera), VIII 507
Three plates.

FERRIS, G. F. Sixth report upon Diptera pupipara from the Philippine Islands 537
Seven text figures.

OHAUS, F. VI. Nachtrag zur Kenntnis der philippinischen Ruteliden (Coleoptera, Lamellicornia) 555
Four text figures.

SANTOS, ALFREDO C. Alkaloid from Anona reticulata Linnæus 561

GARCIA, ONOFRE. Carbohydrate and serological determinations of the bipolar gas-forming and non-gas-forming organisms isolated from lymph glands of slaughtered cattle 565

WHERRY, W. B. Cultivation of an acid-fast Bacillus from leprosy.... 577
One plate.

SCHÖBL, OTTO. Immunologic reciprocity between syphilis and yaws 583

SCHÖBL, OTTO. The immunologic effect of repeated yaws infections interrupted by specific treatment given in the early stage of initial yaw 589

SCHÖBL, OTTO. The duration of antitreponematous immunity with regard to syphilis in Philippine monkeys 595

SCHÖBL, OTTO. The duration of antitreponematous immunity in Philippine monkeys originally conveyed by immunization with killed yaws vaccine 599

SCHÖBL, OTTO. The immunologic effect of antitreponematous vaccine therapy administered after specific treatment which was given in the early stage of initial local yaws in Philippine monkeys 603
One text figure.

REYNOLDS, FRANCOIS H. K., JAMES STEVENS SIMMONS, and JOE H. ST. JOHN. The use of tetanus anatoxin in the protection of horses against infection by Chlostridium tetani 611

REYNOLDS, FRANCOIS H. K., JAMES STEVENS SIMMONS, and JOE H. ST. JOHN. Experimental studies of the treatment of surra 627
Nine text figures.

FRANCISCO, ANACLETO D., and P. J. WESTER. Analysis and food value of some unusual Philippine fruits 655
Nine plates.

INDEX 665

VOL. 43, NO. 1 SEPTEMBER, 1930.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 43 SEPTEMBER, 1930 NO. 1

PHILIPPINE PIPERACEÆ [1]

By EDUARDO QUISUMBING

Botanist, Bureau of Science, Manila

TWENTY-FOUR PLATES AND ONE HUNDRED TWENTY-FOUR TEXT FIGURES

INTRODUCTION

The present paper is the result of a systematic study of the Philippine plants of the family Piperaceæ. Its aim is to present in an intelligible form our present knowledge of this group as it occurs within the area indicated. From an intensive study of the abundant collections and the literature I recognize two genera, with a total of one hundred eight species, eighty-seven in *Piper* and twenty-one in *Peperomia.* This is in rather radical contrast to the late C. de Candolle's work who recognized a total of one hundred fifty-nine Philippine species in the two genera. Fourteen are proposed as new species, of which twelve are *Piper* and two are *Peperomia.* An attempt has been made to make the paper complete so far as Philippine synonymy is concerned, to account for all the species credited to the Islands by previous authors, and to cite the most important literature references under each species. An attempt also has been made to include references to all of the specimens examined.

In the arrangement of the genera I have followed C. de Candolle. In *Piper* two new sections are proposed, *Penninervia* and *Zippelia;* the first embraces all the species belonging in the group with *Piper celtidiforme,* and the latter is typified by

[1] This investigation was carried out at the University of California under a National Research Council Fellowship in the Biological Sciences.

its sole species, *Piper begoniaefolium*. I have placed *Piper copelandii* and *Piper mearnsii* under the section *Eupiper*, removing them from the section *Coccobryon* where they were placed by C. de Candolle.[2]

This study was made mainly at the University of California. The material on which it is based includes all the collections in the herbarium of the Bureau of Science, the material in the herbarium of the University of California, the Gray Herbarium, the United States National Herbarium, and the Kew herbarium, as well as various types and cotypes in certain European herbaria.

All measurements mentioned in the paper are taken from dried specimens with the exception of the bracts, the stamens, and the fruits, the measurements of which are from specimens boiled in water and allowed to dry a little. All photographs are by W. C. Matthews, photographer at the University of California, except Plates 20 to 24, which were made by the Bureau of Science. The drawings are by the author.

It is a pleasure to acknowledge the generous assistance received from many sources. Dr. E. D. Merrill, formerly dean of the College of Agriculture, University of California, under whose supervision and suggestion the study was made, has rendered invaluable aid by his many suggestions and kindly criticisms. I am indebted for the courtesies and facilities extended by the Department of Botany of the University of California. This study could not have been realized but for the aid received from the National Research Council. I am also under obligation to Dr. L. Diels, director of the Botanic Gardens, Berlin; and to Dr. K. M. Malkovsky, of the Prague herbarium, for the loan of types; and to Dr. A. W. Hill, director of the Royal Botanic Gardens at Kew; Dr. A. B. Rendle, British Museum of National History; Dr. B. P. G. Hochreutiner, of Geneva; Dr. A. A. Pulle, of Utrecht; Dr. J. W. C. Goethart, of Leiden; and Dr. F. Gagnepain, of Paris, for the courtesies extended me during my stay in their institutions.

HISTORY

The only important pre-Linnæan publication dealing with Philippine Piperaceæ is Kamel [Herbarium aliarumque stirpium in insula Luzone Philippinarum primaria nascentium . . . in Ray, Hist. Pl. 3 (1704) Suppl. 1–96], who considers and briefly

[2] Candollea 1 (1923) 174.

describes a few species, citing their local names. At the time of the publication of the first edition of Linnæus's "Species Plantarum" in 1753, only twenty piperaceous species were known, three of which are now known to occur in the Philippines. The earliest Philippine Piperaceæ described are those of Blanco, who, in his "Flora de Filipinas" ed. 1, 1837, considers five species of *Piper*. Although his descriptions are vague and imperfect I believe that they are correctly reduced here. Opiz, in Presl's "Reliquiae Haenkeanae," described nine additional species, the collection made by Haenke, a member of the Malaspina Expedition, but two of these were credited to the Archipelago on the basis of erroneously localized specimens. The next work discussing any considerable number of Philippine Piperaceæ is Miquel's "Systema Piperacearum" in 1843, in which nineteen Philippine species of *Piper* and two species of *Peperomia* are described, Miquel having available the series of Piperaceæ in the Cuming Philippine collection distributed in 1841. In 1883, F.-Villar in his "Novissima Appendix" to the third edition of Blanco's "Flora de Filipinas" enumerated thirty-four species of *Piper* and seven species of *Peperomia*, but this is merely a bibliographical list not based on actual specimens, and includes a considerable number of species that do not occur in the Archipelago. In 1885 Vidal listed eleven species of Philippine Piperaceæ with two varieties in his "Phanerogamae Cumingianae Philippinarum" and added one species a year later in his "Revisión de Plantas Vasculares Filipinas." The most-outstanding work on Piperaceæ, which included the Philippine species known up to the time of its publication in 1869, is C. de Candolle's monographic treatment of the family issued in the "Prodomus" where he admits twenty-seven species as occurring in the Archipelago. He described sixteen additional species in Perkins's "Fragmenta Florae Philippinae" in 1905, based mostly on Warburg's collection, and one in Usteri's "Beiträge zur Kenntnis der Philippinen und ihrer Vegetation" based on Usteri's collection. This earlier work was followed by the description of many new species in Elmer's Leaflets of Philippine Botany in 1910 and 1914, and in the Philippine Journal of Science in 1910 and 1916. Merrill published descriptions of three new species in 1920. The latest work of C. de Candolle on Piperaceæ, published subsequent to his death, is his "Piperacearum Clavis Analytica," which appeared in Candollea in 1923, in which the known Piperaceæ of the world are keyed out. Here also appear the names

without descriptions of the four following Philippine species: *Piper sorsogonum*, *Peperomia pauaiana*, *Peperomia ramosii*, and *Peperomia vanoverberghii*. I do not consider that these are properly published and have treated them as nomena nuda. On the basis of an actual examination of the types and isotypes, I fail to discover, except in *Piper sorsogonum*, any distinctive characters, and they have been disposed of in the synonymy of the several species that I believe they represent.

C. de Candolle, in his 1910 revision of the Philippine Piperaceæ, recognized one hundred twenty-five species, of which one hundred three are *Piper* and twenty-two *Peperomia*. Five species of *Piper* and one species of *Peperomia* were added by him in 1914, and in 1916 he proposed twenty-four additional species of *Piper* and in 1923 four others, and Merrill in 1920 described three new species of *Piper*. Thus de Candolle recognized one hundred thirty-three species of *Piper* and twenty-six of *Peperomia* as occurring in the Philippines, to which Merrill added three in 1920. Merrill, in his "Enumeration of Philippine Flowering Plants," made a very considerable number of reductions, most of which I have accepted on the basis of a critical study of the authentic material. He recognized one hundred fifteen species of *Piper*, twenty-five of *Peperomia*, and one *Zippelia*, a total of one hundred forty-one species. Although I am proposing and describing twelve new species of *Piper* and two of *Peperomia* in this paper, I am convinced that Merrill was too conservative in his reductions of the numerous more recently described species. The differences are largely the personal viewpoint as to what constitutes a species. De Candolle described numerous forms as distinct species on what I consider inadequate characters.

GEOGRAPHIC DISTRIBUTION

Ninety-two of the species recognized in this paper are apparently endemic. A large portion of the endemic species are narrowly localized; although some are widely distributed in the Archipelago, as illustrated by such species as *Piper viminale*, *P. philippinum*, and *P. interruptum*.

Two of the species admitted in this paper are pantropic in distribution, *Piper umbellatum* and *Peperomia pellucida*, the former possibly and the latter certainly introduced by man from tropical America. *Peperomia reflexa* is also widely distributed, extending from Polynesia to South Africa, but is manifestly of natural distribution. The only species cultivated in the Phil-

ippines are *Piper nigrum*, *P. betle*, and *Peperomia argyreia;* the first two originated in Indo-Malaysia, the last in tropical America. *Peperomia argyreia* and *Piper nigrum* are not found outside of cultivation, but various forms of *Piper betle* are abundant in nature, and perhaps are actually native of the Philippines.

In the Philippine Piperaceæ the percentage of endemism is high in the primary forests; yet several characteristic species are widely distributed outside of the Archipelago, particularly in Western Malaysia. There are also some endemics that are manifestly closely allied to species occurring outside of the Philippines, thus indicating probable common origins. Of the species recorded from New Guinea, *Piper celtidiforme* (*P. corylistachyon*), *P. caninum*, and *P. fragile* occur in the Philippines. It is of interest to note that *Piper celtidiforme* has not been found in Western Malaysia. On the other hand a considerable number of Philippine-Western-Malaysian species do not extend to Eastern Malaysia; such as, *Piper baccatum*, *P. begoniaefolium*, *Peperomia recurvata*, and *P. tomentosa*. *Piper korthalsii* and *P. abbreviatum* occur in the Philippines as well as in Western Malaysia, while *Piper arborescens* and *Piper majusculum* have a wider range, extending to Amboina; that is, Eastern Malaysia. *Piper interruptum*, *P. elmeri*, and *P. longivaginans* are very closely allied to some of the Western Malaysian species. In general it appears that the alliance of Philippine Piperaceæ is stronger with Western than with Eastern Malaysia.

MORPHOLOGY

PIPER

More or less scandent shrubs with woody or somewhat woody stems, rarely erect. Branches glabrous or pubescent, usually terete, canaliculate, smooth or rugose. Leaves entire, alternate; lamina membranaceous, chartaceous, or coriaceous, small (*Piper curtifolium*) or large (*Piper elmeri*, *P. decumanum*, *P. subprostratum*), linear to broadly ovate, glabrous to densely pubescent, apices obtuse or rounded to acute or acuminate, bases auriculate (*Piper aurilimbum*), acute, obtuse, or rounded, or strongly cordate (*Piper cordatilimbum*), equilateral or inequilateral, venation nerved, plinerved or penninerved; nerves and nervules prominent or obscure; petioles very short or long, entirely glabrous or densely pubescent, winged or terete; stipules usually absent.

The *Piper arborescens* group presents a unique feature in a swollen structure, which has the appearance of a gland, at the

extreme base of the lamina adjacent to the petiole. It is technically a hydathode but is usually described as an auricle or lobule. *Piper myrmecophilum* is another very characteristic species, the leaf base forming a sac, the domicile of ants, whence its scientific name.

Pistillate spikes erect or pendulous (Plate 17), short, oblong, ovoid or globose (*Piper abbreviatum*) or greatly elongated and cylindric (*Piper arborescens*). Rachis usually pubescent, rarely glabrous. Peduncles very short or long (*Piper tenuipedunculum*), slender or thick, glabrous or densely pubescent. Bracts peltate or nonpeltate, sessile or pedicellate, adnate to the rachis (*Piper interruptum*) or cupular (*Piper baccatum*), glabrous or densely pubescent; pedicels slender or stout, glabrous or pubescent. Ovary 1-celled, 1-ovuled. Fruits usually yellow or red, small (*Piper arborescens*) or large (*Piper baguionum*), concrescent or free, partly or wholly embedded in the pulp (*Piper betle*), sessile or stipitate, ovoid, ellipsoid, oblong, or globose, smooth or glabrous, tubercular, pubescent or glochidiate. Styles very short or elongated. Stigmas usually sessile or short or sometimes elongated (*Piper longistigmum*). Seeds free from the pulp or adherent, terete or angled.

Staminate spikes usually normal, sometimes pseudohermaphrodite, erect or pendulous, short or greatly elongated, cylindric. Rachis usually slender and pubescent, rarely glabrous. Bracts smaller than those of the pistillate spikes, peltate or nonpeltate, sessile or pedicellate. Stamens two or three in nearly all species (one in *Piper korthalsii*, five in *Piper baccatum*, six in *Piper begoniaefolium* and eight in *Piper sarcopodum*), usually exerted; anthers usually oblong, rarely ovoid or globose; loculi two or four; connective above the loculi usually nonabortive and thickened, in section *Penninervia* the connective enlarged; filaments usually slender, short or somewhat elongated, in *Piper korthalsii* enlarged and fleshy.

All species of the genus are more or less aromatic, with a characteristic pungent odor and taste.

PEPEROMIA

Small annual or perennial, more or less aromatic, often fleshy herbs, mostly terrestrial, few epiphytic or semiepiphytic (*Peperomia elmeri*), erect, prostrate or decumbent, simple or profusely branched, glabrous or pubescent. Leaves alternate, opposite or whorled; lamina entire, lanceolate, ovate, obovate, broadly rounded-ovate or cordate, when fresh usually more or

less succulent, thinly membranaceous, chartaceous or coriaceous when dry, glabrous to densely pubescent, venation nerved or plinerved; petioles glabrous or pubescent, without stipules.

Spikes hermaphroditic, leaf-opposed, axillary or terminal, solitary or umbellate, loosely to densely flowered. Rachis glabrous or pubescent in *Peperomia reflexa*. Bracts peltate, sessile or subsessile, disk usually orbicular, thinly membranaceous to fleshy, glabrous or pubescent. Ovary free or immersed in the rachis, ovoid to globose. Stigmas usually very minute and inconspicuous, terminal or situated below the apex or on the anterior side, single and entire, bilobed or penicillate. Fruits minute, free or immersed in the rachis, ovoid to globose, smooth, striate-costulate or verruculose. Stamens always two, usually deciduous after anthesis, anthers 2-valved, ovoid to globose, filaments short or elongated, glabrous or pubescent.

Plants in general with the same aroma as *Piper*, but the odor and the taste of the fresh material are less pronounced.

Key to the Philippine genera of Piperaceæ.

1. Woody or semiwoody, usually scandent, rarely erect shrubs or undershurbs; flowers unisexual or bisexual; vascular bundle double; leaves alternate; fruits never minute; stamens 1 to 8, anthers tetralocular or bilocular, 2- to 4-valved; bracts free, pedicellate or sessile, peltate or adnate to the rachis, with margin and apex free or cupular. 1. *Piper*.
1. Small herbaceous succulent plants; flowers bisexual; vascular bundle simple or scattered; fruits minute; stamens 2, anthers unilocular, 2-valved; bracts free, peltate; leaves alternate, opposite or whorled. 2. *Peperomia*.

Genus PIPER Linnæus

Key to the sections of Piper.

1. Bracts free, pedicellate or sessile, peltate.
   2. Spike umbellate, axillary; flowers bisexual .... § I. *Heckeria*.
   2. Spike solitary, leaf-opposed; flowers unisexual or bisexual.
      3. Connective of anthers never enlarged; lamina nerved, plinerved or penninerved.
         4. Fruits never glochidiate; stamens 2 or 3................ § II. *Eupiper*.
         4. Fruits glochidiate; stamens 6.................................... § VI. *Zippelia*.
      3. Connective of anthers enlarged; lamina penninerved. § V. *Penninervia*.
1. Bracts adnate to the rachis, margin and apex free; spike solitary, leaf-opposed.
   2. Filaments never enlarged; stamens 2 or 3 .... § II. *Eupiper*.
   2. Filaments enlarged; stamen 1.................................... § III. *Sarcostemon*.
1. Bracts cupular; stamens 5 or 8; spike solitary, leaf-opposed. § IV. *Muldera*.

Key to the species of Piper.[3]

1. Lamina subpeltate to peltate.
   2. Spikes umbellate, axillary, numerous; flowers bisexual; lamina large, broadly ovate to suborbicular-ovate; stigmas sessile.
   1. *P. umbellatum* var. *subpeltatum*.
   2. Spike never umbellate, solitary, leaf-opposed; flowers diœcious.
      3. Lamina oblong; styles long .... 43. *P. angustipeltatum*.
      3. Lamina elliptic-ovate to rounded-ovate; styles short.
      44. *P. fragile*.
1. Lamina never subpeltate to peltate.
   2. Leaf-base subauriculate to auriculate.
      3. Lamina nerved; that is, ascending nerves leaving the midrib at the very base of the leaf; bracts pedicellate, apex of disk subulate; styles long; fruits free................................ 5. *P. brevicuspe*.
      3. Lamina penninerved.
         4. Staminate spikes 4.5 to 8 cm long.
            5. Branches, petioles, and nerves on the lower surface of the lamina black; anthers subglobose........ 19. *P. aristolochiphyllum*.
            5. Branches, petioles, and nerves on the lower surface of the lamina never black; anthers oblong.................... 18. *P. merrillii*.
         4. Staminate spikes 26 to 43 cm long................ 14. *P. majusculum*.
      3. Lamina plinerved; that is, ascending nerves leaving the midrib above the base of the leaf.
         4. Styles very long; leaf myrmecophilous; that is, supplied with a saclike body at the base forming a dwelling place for ants.
         21. *P. myrmecophilum*.
         4. Styles subsessile to sessile; leaf never myrmecophilous.
            5. Lamina glabrous on both surfaces.
               6. Pistillate spikes 25 to 30 cm long; lamina large (28 to 43 by 11 to 25 cm), broadly oblong-ovate to broadly ovate .... 12. *P. decumanum*.
               6. Pistillate spikes not exceeding 4 cm in length; lamina not large (15 to 30 by 2 to 3.4 cm), narrowly lanceolate.
               52. *P. ensifolium*.
            5. Lamina glabrous above, pubescent beneath.
               6. Pistillate spikes greatly elongated, cylindric and slender (25 to 90 by 5 to 10 mm).
                  7. Pistillate bracts long-pedicellate.
                     8. Lamina hirsute to villose on the nerves beneath; branches glabrous to villose.
                        9. Lamina broadly ovate-elliptic, oblong-elliptic or elliptic-lanceolate (5 to 16.5 cm wide).. 10. *P. lessertianum*.
                        9. Lamina narrowly elliptic-lanceolate (2.5 to 6 cm wide).
                        10. *P. lessertianum* var. *oblongibaccum*.
                     8. Lamina minutely puberulent on the nerves beneath; branches minutely puberulent ....11. *P. subprostratum*.

[3] Artificial key without regard to sections.

7. Pistillate bracts subsessile to sessile; lamina pilose on the nerves and puberulent on the parenchyma; branches pilose .... 17. *P. agusanense.*
6. Pistillate spikes oblong (15 to 43 by 6 to 11 mm).
7. Pistillate bracts long-pedicellate (1.2 to 2.5 mm long); stamens subsessile to sessile........ 18. *P. merrillii.*
7. Pistillate bracts pedicellate (0.8 to 1.2 mm long); stamens subpedicellate .... 20. *P. aurilimbum.*
5. Lamina pubescent on both surfaces.
6. Lamina narrowly oblong-ovate to ovate-lanceolate, apex narrowed, acute, nerves beneath never dark brown; pistillate peduncles 4 to 6 mm long........ 35. *P. ramosii.*
6. Lamina oblong-ovate to ovate, apex acutely acuminate; nerves dark brown; pistillate peduncles 10 to 18 mm long.
36. *P. fuscinervum.*
2. Leaf-base equilateral to inequilateral, acute to rounded, never auriculate.
3. Lamina nerved; that is, ascending nerves leaving the midrib at the very base of the leaf.
4. Pistillate spikes greatly elongated, slender and cylindric (90 to 275 by 3 to 7 mm); fruits crowded.
5. Lamina glabrous on both surfaces, apex acutely acuminate to long and acutely acuminate.
6. Lamina ovate-lanceolate to oblong-ovate.... 2. *P. arborescens.*
6. Lamina narrowly oblong-lanceolate to elliptic-lanceolate.
2. *P. arborescens* var. *angustilimbum.*
5. Lamina glabrous above, pubescent on the nerves beneath.
6. Lamina ovate-lanceolate to oblong-ovate, apex acutely acuminate to long and acutely acuminate.
2. *P. arborescens* var. *hirtellum.*
6. Lamina elliptic to oblong-ovate, apex short and obtusely acuminate .... 3. *P. trichophlebium.*
5. Lamina pubescent on both surfaces, apex acutely acuminate to slenderly and acutely acuminate........ 4. *P. pilipes.*
4. Pistillate spikes elongated, interrupted (30 to 175 by 8 to 15 mm), fruits never crowded.
5. Fruits glochidiate, remote; stamens 6.... 89. *P. begoniaefolium.*
5. Fruits never glochidiate and never remote; stamens 2 or 3.
6. Stigmas 5 or 6 .... 75. *P. multistigmum.*
6. Stigmas 3 or 4.
7. Rachis pubescent.
8. Lamina lanceolate .... 77. *P. elliptibaccum.*
8. Lamina oblong-elliptic to ovate........ 72. *P. interruptum.*
8. Lamina broadly oblong.
72. *P. interruptum* var. *laevirameum.*
8. Lamina elliptic-ovate to rounded-ovate.
72. *P. interruptum* var. *loheri.*
8. Lamina narrowly elliptic-lanceolate to narrowly oblong-elliptic .... 72. *P. interruptum* var. *cumingianum.*

7. Rachis glabrous.
   8. Lamina oblong-elliptic to ovate-elliptic; bracts oblong-obovate .... 74. *P. pulogense.*
   8. Lamina lanceolate; bracts spathulate. 76. *P. spathelliferum.*

4. Pistillate spikes short, oblong to ovoid (8 to 25 mm long); fruits somewhat crowded.
   5. Lower leaves usually subpeltate; lamina elliptic-ovate to elliptic-rounded-ovate; stigmas 4 or 5........ 44. *P. fragile.*
   5. Lower leaves never subpeltate; stigmas 3 or 4.
      6. Lamina glabrous on both surfaces.
         7. Lamina narrowly oblong-lanceolate (8.5 to 11 by 2 to 2.5 cm), base subacute, apex narrowed; fruits ovoid. 26. *P. cacuminum.*
         7. Lamina narrowly linear, ovate-lanceolate or ovate (4 to 12.5 by 0.4 to 3.3 cm), base repand to cordate, apex narrowed, acute, with a minute apiculum; fruits globose to oblong-obovoid........ 25. *P. costulatum.*
         7. Lamina small, ovate to elliptic-ovate (2.5 to 6.5 by 1 to 3.5 cm), base usually acute, sometimes obtuse, apex shortly and acutely acuminate; fruits globose to subglobose. 31. *P. curtifolium.*
         7. Lamina elliptic-ovate (6 to 8.2 by 3 to 4.5 cm), base acute, apex shortly and obtusely acuminate; fruits globose. 32. *P. varibracteum.*
         7. Lamina ovate-lanceolate to elliptic-lanceolate (6 to 15 by 1.5 to 5.5 cm), base acute to subrounded, apex attenuate; fruits oblong to oblong-ovoid........ 27. *P. halconense.*
         7. Lamina oblong-ovate (6 to 7.8 by 2.5 to 3.8 cm), base acute to obtuse, apex acutely acuminate; fruits globose. 28. *P. atrospicum.*
      6. Lamina glabrous above, more or less pubescent on the nerves beneath.
         7. Nerves on the lower surface sparingly hirsute; lamina ovate-lanceolate to elliptic-lanceolate, base acute to subrounded, apex attenuate........ 27. *P. halconense.*
         7. Nerves on the lower surface conspicuously and densely hirtellous; lamina ovate, base rounded, apex shortly and acutely acuminate .... 33. *P. mindorense.*

3. Lamina plinerved; that is, ascending nerves leaving the midrib above the base of the leaf.
   4. Pistillate spikes elongated and slender, up to 220 mm long, 3.5 to 8 mm in diameter.
      5. Lamina glabrous on both surfaces.
         6. Fruits crowded or somewhat crowded.
            7. Lamina large (11 to 23 by 3.5 to 9.3 cm), elliptic-lanceolate to elliptic-ovate-lanceolate; pistillate spikes long (6.8 to 21.5 cm long); staminate bracts pedicellate; stamens pedicellate, anthers ovoid to globose-ovoid; fruits crowded .... 8. *P. urdanetanum.*

7. Lamina small (7.5 to 11.8 by 1.7 to 3.3 cm), elliptic-lanceolate; pistillate spikes short (4.5 to 5 cm long); staminate bracts sessile; stamens subsessile, anthers reniform; fruits somewhat crowded........................ 9. *P. simile.*

6. Fruits laxly arranged; lamina small, ovate (7.5 to 10.8 by 3.6 to 5.8 cm); pistillate spikes short (2 to 3.6 cm long.) 16. *P. melanocaulon.*

5. Lamina glabrous above, pubescent beneath.

6. Lamina puberulent on the nerves only.

7. Lamina broadly ovate, large (21.5 to 28.5 by 15.5 to 19.5 cm), base broadly and deeply cordate; pistillate spikes greatly elongated (19.5 to 22 cm long), peduncles 10 to 15 cm long .... 13. *P. lageniovarium.*

7. Lamina ovate, small (7.5 to 10.2 by 3.2 to 6 cm), base never cordate; pistillate spikes not greatly elongated (7 to 8.5 cm long), peduncles 3.5 to 4.6 cm long. 15. *P. eupodum.*

6. Lamina hirsute on the nerves and parenchyma, ovate-lanceolate to elliptic-lanceolate................................ 17. *P. toppingii.*

5. Lamina oblong-lanceolate, densely pubescent on both surfaces and margin .... 6. *P. medinillifolium.*

4. Pistillate spikes not slender (7 to 90 by 5 to 25 mm).

5. Fruits not free or free only about the apex, base partly or fully embedded in and concrescent with the rachis.

6. Stigmas elongated.

7. Nerves on the lamina not sunken above; lamina brown; petioles glabrous .... 41. *P. longistigmum.*

7. Nerves on the lamina sunken above; lamina pale; petioles pubescent to somewhat glabrous .... 40. *P. firmolimbum.*

6. Stigmas never elongated, sessile, apical.

7. Styles long .... 42. *P. baguionum.*

7. Styles none.

8. Fruits free at the apex, base partly embedded in and concrescent with the rachis.

9. Leaves membranaceous to subcoriaceous; true staminate spikes with no pseudohermaphrodite flowers.

10. Young branches glabrous.

11. Lamina glabrous on both surfaces.

12. Lamina dark brown to black when dry; petioles vaginate their whole length. 29. *P. longivaginans.*

12. Lamina never dark brown when dry; petioles not vaginate their whole length.

13. Lamina elliptic-ovate (6 to 8.2 by 3 to 4.5 cm), chartaceous to subcoriaceous, base acute .... 32. *P. varibracteum.*

13. Lamina narrowly linear, ovate-lanceolate or ovate (4 to 12.5 by 0.4 to 3.3 cm), membranaceous, base repand to cordate. 25. *P. costulatum.*

13. Lamina ovate-lanceolate to elliptic-lanceolate (6 to 15 by 1.5 to 5.5 cm), membranaceous, base acute to subrounded.
27. *P. halconense.*

13. Lamina narrowly ovate-lanceolate to narrowly elliptic-lanceolate (3 to 9 by 0.6 to 2 cm), chartaceous, base acute.
30. *P. delicatum.*

11. Lamina glabrous above, pubescent on the nerves beneath.

12. Lamina dark brown to black when dry; petioles vaginate their whole length.
29. *P. longivaginans.*

12. Lamina never dark brown when dry; petioles not vaginate their whole length.

13. Petioles vaginate about half-way their whole length; fruits oblong to oblong-ovoid; staminate spikes suberect, curved at the apex.
27. *P. halconense.*

13. Petioles vaginate at the base; fruits obovoid; staminate spikes erect, never curved at the apex .... 30. *P. delicatum.*

10. Young branches pubescent.

11. Spikes hermaphroditic; that is, bearing both ♂ and ♀ flowers; lamina glabrous above, hirtellous on the nerves beneath, ovate-elliptic (12.5 to 16 by 6.5 to 9.5 cm), chartaceous, base cuneate.
47. *P. parong.*

11. Spikes diœcious; that is, bearing only ♂ or ♀ flowers.

12. Base of the lamina acute to obtuse, never subcordate to cordate.

13. Lamina glabrous above, pubescent on the nerves beneath, narrowly ovate-lanceolate to narrowly elliptic-lanceolate; anthers globose .... 30. *P. delicatum.*

13. Lamina pubescent on both surfaces, narrowly elliptic-lanceolate to ovate; anthers ovoid .... 34. *P. ovatibaccum.*

12. Base of the lamina subcordate to cordate; lamina glabrous above, minutely puberulent on the nerves beneath, upper leaves elliptic-ovate, oblong-ovate or ovate.
45. *P. sarmentosum.*

9. Leaves coriaceous; staminate spikes pseudohermaphroditic; that is, bearing fertile ♂ flowers and sterile ♀ flowers.

10. Lamina elliptic-lanceolate, oblong-elliptic, subovate-elliptic, subobovate-elliptic or ovate (10 to 25 by 4.5 to 11 cm) .... 49. *P. philippinum.*

10. Lamina broadly oblong-elliptic to broadly oblong-ovate (14.5 to 28.5 by 6.5 to 18 cm).
50. *P. albidirameum.*
10. Lamina broadly elliptic-ovate to broadly rounded-ovate (14.5 to 35 by 10.5 to 27.5 cm).
51. *P. maagnasanum.*
8. Fruits not free, base or the whole embedded in and concrescent with the rachis.
9. Spikes hermaphroditic; that is, bearing both ♂ and ♀ flowers; young branches minutely puberulent; lamina glabrous above, minutely puberulent on the nerves beneath, oblong-ovate to rounded-ovate, 7- to 9-plinerved .... 46. *P. sibulanum.*
9. Spikes diœcious; that is, bearing only ♂ or ♀ flowers.
10. Lamina glabrous on both surfaces.
11. Pistillate spikes not shortened (2.5 to 8 cm long), apex of fruit never umbonate; seeds oblong to globose-obvoid.
12. Lamina chartaceous to subcoriaceous, oblong-ovate, oblong-elliptic, ovate or rounded-ovate (6 to 17.5 by 3.5 to 10 cm); spikes oblong to elongated oblong, up to 1 cm in diameter.
37. *P. betle.*
12. Lamina chartaceous, subovate-elliptic (5 to 7 by 1.8 to 3.8 cm); spikes oblong, up to 0.8 cm in diameter .... 38. *P. langlassei.*
12. Lamina firmly coriaceous, oblong-ovate (8 to 12.5 by 4 to 6 cm); spikes oblong-ovoid to oblong-obovoid, up to 1.7 cm in diameter.
39. *P. asterostigmum.*
11. Pistillate spikes abbreviated (0.7 to 2 cm long); apex of fruit umbonate, the product of somewhat elongated styles; seeds obovoid, oblong-obovoid, or oblanceolate.... 22. *P. abbreviatum.*
10. Lamina glabrous above, pubescent on the nerves beneath.
11. Base of the lamina never subcordate to cordate.
46. *P. sibulanum.*
11. Base of the lamina subcordate to cordate.
37. *P. betle* var. *densum.*
5. Fruits free, sessile to stipitate.
6. Fruits borne on a cupular receptacle.
7. Cupular receptacle sessile to subsessile; stamens 5.
81. *P. baccatum.*
7. Cupular receptacle stipitate; stamens 8.
82. *P. sarcopodum.*
6. Fruits never borne on a cupular receptacle.
7. Fruits stipitate.
8. Pistillate bracts adnate to the rachis, apex and margin free.

9. Lamina glabrous on both surfaces, ovate (10 to 17 by 6.5 to 10.5 cm), base rounded; fruits not large (4 to 6.5 by 3 to 5 mm), pedicels up to 5 mm long. 70. *P. sorsogonum.*
9. Lamina glabrous above, densely and softly pubescent beneath, broadly ovate (15 to 28 by 11 to 23 cm) base deeply cordate; fruits large (7 to 9 by 6.5 to 8 mm), pedicels up to 15 mm long........ 71. *P. elmeri.*

8. Pistillate bracts never adnate to the rachis, free and peltate.
   9. Bracts ciliate on the margin.
      10. Fruit pedicels long, up to 9 mm. 65. *P. longipedicellatum.*
      10. Fruit pedicels not exceeding 5 mm in length.
         11. Lamina glabrous on both surfaces.
            12. Lamina subcoriaceous, elliptic-ovate to elliptic-ovate-lanceolate; bracts ciliate above; young and old branches glabrous. 64. *P. cabadbaranum.*
            12. Lamina chartaceous, narrowly linear, narrowly oblong-ovate to narrowly ovate-lanceolate in the male, oblong-lanceolate to oblong-ovate in the female; bracts glabrous above; young branches pubescent, old glabrous. 54. *P. viminale.*
         11. Lamina glabrous to more or less pubescent on the midrib above, usually pubescent beneath, rarely glabrous.
            12. Lamina narrowly linear, narrowly oblong-ovate to narrowly ovate-lanceolate in the male, oblong-lanceolate to oblong-ovate in the female, apex narrowed, acumen subobtuse to obtuse.. 54. *P. viminale.*
            12. Lamina oblong-ovate to ovate, apex acutely acuminate .... 53. *P. caninum.*
   9. Bracts glabrous on the margin.
      10. Pistillate peduncles long, up to 5 cm. 60. *P. tenuipedunculum.*
      10. Pistillate peduncles not exceeding 3 cm.
         11. Lamina glabrous on both surfaces.
            12. Fruits fusiform; lamina lanceolate. 66. *P. arborisedens.*
            12. Fruits never fusiform.
               13. Acumen of lamina subobtuse to obtuse.
                  14. Fruits subglobose, not crowded, puberulent; branches glabrous; apex of lamina attenuate .... 55. *P. apoanum.*
                  14. Fruits ellipsoid or subglobose, glabrous, crowded; branches tomentose; apex of lamina acuminate........ 56. *P. densibaccum.*

13. Acumen of lamina acute; fruits glabrous, not crowded.
    14. Lamina oblong-ovate, apex acute, bracts oblong-ovate to orbicular.
    57. *P. dagatpanum.*
    14. Lamina elliptic-lanceolate, apex acuminate; bracts transversely elliptic.
    68. *P. paucinerve.*
    14. Lamina oblong-elliptic, apex acuminate; bracts orbicular.. 58. *P. dipterocarpinum.*

11. Lamina glabrous above, more or less pubescent beneath.
    12. Fruits fusiform; lamina elliptic-lanceolate; young and old branches pubescent.
    67. *P. acutibaccum.*
    12. Fruits never fusiform; young and old branches glabrous.
        13. Lamina ovate-lanceolate to oblong-subelliptic, base acute to subobtuse; fruits 3.5 to 4.5 mm long; bracts rounded-obovate to orbicular, 0.75 to 1.25 mm wide.
        53. *P. caninum* var. *glabribracteum.*
        13. Lamina ovate, base rounded; fruits 5 to 7 mm long; bracts transversely elliptic, 1.75 to 2.1 mm long, 1.25 to 1.75 mm wide.
        59. *P. sablanum.*

11. Lamina more or less pubescent above, copiously pubescent beneath.
    12. Fruits large, oblong-ellipsoid to ovoid-globose (5 to 6.5 by 3 to 4.75 mm).
        13. Lamina oblong-elliptic to oblong-ovate; lower leaves never heart-shaped, dark brown; bracts oblong-ovate.... 61. *P. malalaganum.*
        13. Lamina ovate, lower leaves heart-shaped, olivaceous; bracts orbicular.
        53. *P. caninum* var. *latibracteum.*
    12. Fruits small, ovoid, ovoid-globose to obovoid-globose (2.5 to 4.5 by 2 to 3.5 mm).
        13. Lamina strictly oblong.
        53. *P. caninum* var. *oblongifolium.*
        13. Lamina not strictly oblong.
            14. Lamina oblong-elliptic to oblong-ovate, pubescent on the nerves only.
            53. *P. caninum* var. *lanaoense.*
            14. Lamina pubescent on both nerves and parenchyma.
                15. Fruit pedicels up to 2.75 mm long; lamina elliptic-lanceolate to elliptic-ovate, acumen acute.
                53. *P. caninum* var. *hallieri.*

15. Fruit pedicles up to 1 mm long; lamina ovate to ovate-lanceolate, acumen obtuse .... 53. *P. caninum* var. *basilanum.*

11. Lamina copiously pubescent on both surfaces.

12. Lamina oblong-ovate, oblong-lanceolate, elliptic-ovate, or ovate-lanceolate, lower leaves heart-shaped, pistillate bracts orbicular.
62. *P. haenkeanum.*

12. Lamina broadly heart-shaped; pistillate bracts transversely oblong........ 63. *P. cordatilimbum.*

7. Fruits sessile, rarely subsessile.

8. Fruits without a hot taste.

9. Stamen 1, filament swollen, fleshy; fruits large, ovoid-connate, apex rostrate-attenuate.... 80. *P. korthalsii.*

9. Stamens 2 or 3, filaments never swollen; fruits small, apex never rostrate-attenuate.

10. Staminate bracts fully imbricate, stamens never exerted .... 73. *P. davaoense.*

10. Staminate bracts never fully imbricate, stamens exerted.

11. Lamina glabrous on both surfaces; pistillate bracts adnate to the rachis, margin and apex free.

12. Lamina lanceolate........... 77. *P. elliptibaccum.*

12. Lamina narrowly elliptic-lanceolate to narrowly oblong-elliptic.
72. *P. interruptum* var. *cumingianum.*

12. Lamina broadly oblong to oblong-elliptic.
72. *P. interruptum* var. *multiplinerve.*

12. Lamina broadly ovate............ 78. *P. clemensiae.*

11. Lamina glabrous above, more or less pubescent on the nerves beneath; pistillate bracts free, sessile, peltate .... 69. *P. brevistigmum.*

8. Fruits with a hot taste, globose, apex rounded; stamens 2, filaments not swollen.... 79. *P. nigrum* var. *trioicum.*

3. Lamina penninerved.

4. Connective of anthers never enlarged.

5. Spikes hermaphroditic; that is, bearing both ♂ and ♀ flowers; pistillate bracts sessile; rachis hirsute; stamens pedicellate.

6. Lamina glabrous on both surfaces........ 23. *P. breviamentum.*

6. Lamina glabrous above, puberulent on the nerves beneath.
23. *P. breviamentum* var. *puberulinervum.*

5. Spikes diœcious; that is, bearing only ♂ or ♀ flowers.

6. Lamina glabrous on both surfaces; pistillate bracts sessile; rachis glabrous; stamens sessile.......... 48. *P. retrofractum.*

6. Lamina glabrous above, pubescent on the nerves beneath; pistillate bracts long-pedicellate; rachis villose; stamens pedicellate .... 24. *P. parcirameum.*

4. Connective of anthers enlarged.

5. Fruits crowded; stigmas not sessile, up to 0.5 mm long; lamina glaucous beneath.

6. Lamina glabrous on both surfaces; connective above the loculi subacute to truncate .... 83. *P. celtidiforme.*
6. Lamina glabrous above, subglabrous to pubescent on the nerves beneath; connective above the loculi rounded.
   7. Branches glabrous; lamina oblong-elliptic to lanceolate-elliptic; petioles vaginate their whole length with the base broadly vaginate and chartaceous, glabrous. 83. *P. celtidiforme* var. *vaginans.*
   7. Branches pubescent; lamina lanceolate to oblong-ovate; petioles subvaginate, pubescent.............. 84. *P. catubigense.*
5. Fruits never crowded; stigma sessile; lamina never glaucous beneath.
   6. Lamina glabrous on both surfaces; fruits never tubercular. 85. *P. peninerve.*
   6. Lamina glabrous above, pubescent beneath; fruits tubercular. 86. *P. villirache.*

Section HECKERIA

HOOK. f. in Fl. Brit. Ind. 5 (1890) 95; C. DC. in Candollea 1 (1923) 169.

Leaves broadly ovate to suborbicular-ovate, multiplinerved, bases subpeltate, deeply cordate. Spikes numerous, erect, umbellate, axillary. Flowers bisexual. Bracts free, pedicellate, peltate. Fruits sessile, crowded. Stamens 2.

1. PIPER UMBELLATUM Linn. var. SUBPELTATUM (Willd.) C. DC. Text fig. 1; Plate 17, fig. 11.

Piper umbellatum LINN., Sp. Pl. (1762) ed. 2, 43, var. *subpeltatum* (Willd.) C. DC. in Donn.-Sm. Enum. 6: 39, Philip. Journ. Sci. 5 (1910) Bot. 463, 11 (1916) Bot. 225, Candollea 1 (1923) 170; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper subpeltatum WILLD., Sp. Pl. 1 (1797) 166; VAHL, Enum. 1 (1805) 337; C. DC., Prodr. 16^1 (1869) 333; F.-VILL., Novis. App. (1880) 176; VIDAL, Phan. Cuming. Philip. (1885) 138; Rev. Pl. Vasc. Filip. (1886) 220.

Heckeria subpeltata KUNTH in Linnaea 13 (1839) 571.

Pothomorphe subpeltata MIQ., Comment. Phytogr. (1840) 36, Syst. Pip. (1843) 213, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 29, *t. 36.*

Piper umbellatum Linn. var. *glabrum* C. DC. in Bull. Herb. Boiss. 16 (1898) 494, Leafl. Philip. Bot. 3 (1910) 789, Philip. Journ. Sci. 11 (1916) Bot. 225, Candollea 1 (1923) 170; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper peltatum USTERI, Beitr. Ken. Philip. Veg. (1905) 125 (sphalm) non Linn.

Erect, suffrutescent, 1 to 2 meters high; the branches glabrous, thick, glandular, subterete, canaliculate. Leaves membranaceous, with conspicuous glandular brown to black dots beneath, broadly ovate to suborbicular-ovate, 17 to 37.5 cm

long, 15 to 32 cm wide, base subpeltate, multiplinerved; equilaterally deeply cordate, lobes rounded, apex shortly and acute acuminate, hirtellous on the nerves on both surfaces, margin ciliate, reticulations prominent on both surfaces; petioles very long, more or less hirtellous, 11.5 to 27.5 cm long. Spikes numerous, umbellate, axillary, erect, hermaphroditic, 5.5 to 12 cm long, 2 to 3.5 mm in diameter; main branch of the inflorescence puberulent, 1.2 to 4 cm long, the peduncles of the spikes slender, 5 to 12 mm long; rachis glabrous; bracts pedi-

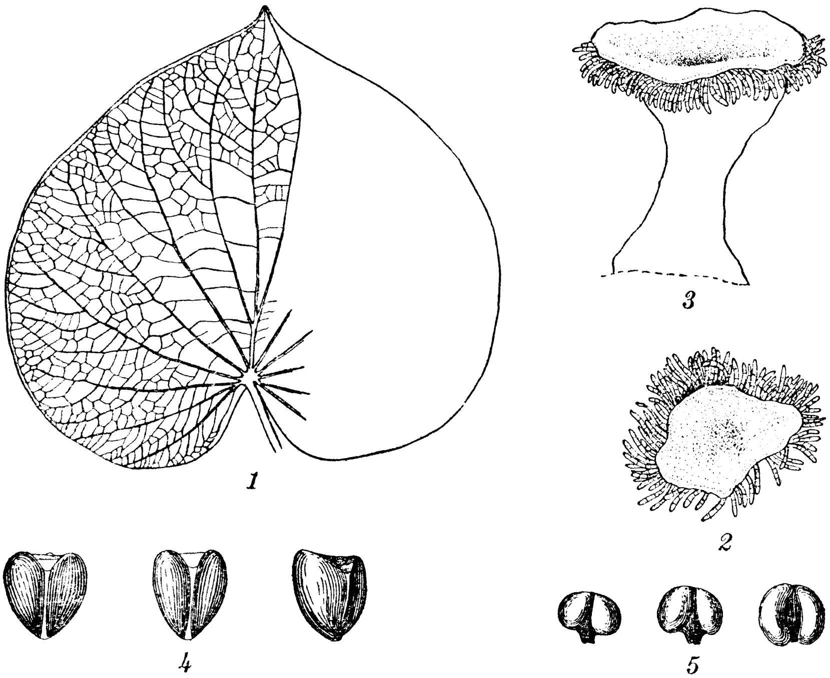


FIG. 1. *Piper umbellatum* Linn. var. *subpeltatum* (Willd.) C. DC.; *1*, leaf, × 0.25; *2*, top view of bract, × 5; *3*, side view of bract, × 5; *4*, seeds, × 12.5; *5*, stamens, × 40.

cellate, peltate, about 1 mm long, disk semilunar, triangular, margin ciliate, subfleshy, about 0.5 mm wide; fruits free, crowded, obovoid-trigonous, 0.75 to 1 mm long, about 0.5 mm in diameter, glandular, apex truncate, umbonate; stigmas, cuspidate; stamens 2, subsessile, minute, up to 0.2 mm long, anthers subglobose, bilocular, 2-valved, filaments very much shorter than the anthers.

LUZON, Ilocos Norte Province, Bangui, *Bur. Sci. 7711 Ramos:* Isabela Province, San Mariano, *Bur. Sci. 47252 Ramos and Edaño:* Apayao Subprovince, Aguimi, *Bur. Sci. 28138 Fénix:*

Bontoc Subprovince, Antadao, *Vanoverbergh 383:* Benguet Subprovince, Sablan, *Bur. Sci 12694 Fénix:* Bulacan Province, Babuan, Maon River, *Philip. Pl. 1940 Ramos:* Bataan Province, Lamao River, Mount Mariveles, *Williams 334:* Rizal Province, Bosoboso, *Bur. Sci. 1018 Ramos, For. Bur. 3315 Ahern's collector;* Antipolo, *Bur. Sci. 20986 Ramos;* Montalban, *Loher 13412;* Caysusot, *Philip. Pl. 42 Ramos:* Laguna Province, Paete, *Bur. Sci. 22827, 22846 McGregor;* near Fami, *Bur. Sci. 23183 McGregor;* Pililla-Mabitac trail, *Bur. Sci. 11946 Robinson and Ramos;* Los Baños, *Bur. Sci. 6723 Robinson, Baker 380;* Mount Maquiling, *Bur. Sci. 16897 Siriñas, Foxworthy, and Forestry Squad 11, For. Bur. 20872bis Villamil, Elmer 17594;* Calauan, *Cuming 441, Bur. Sci. 12414 McGregor;* Lazaan, *Bur. Sci. 6030 Robinson:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 15625.* MINDORO, Mount Cabignayan, *For. Bur. 8678 Merritt;* Paluan, *Bur. Sci. 39595 Ramos.* PANAY, Capiz Province, Jamindan, *Bur. Sci. 31253 Ramos and Edaño:* Libacao, *Bur. Sci. 35404 Martelino and Edaño:* Antique Province, Culasi, *Bur. Sci. 5915 McGregor.* CAMIGUIN DE MINDANAO, Canangcaan, *Bur. Sci. 14723 Ramos.* MINDANAO, Bukidnon Province, Sumilau, *Bur. Sci. 15787 Fénix;* Mount Candoon, *Bur. Sci. 38767 Ramos and Edaño:* Lanao Province, Lake Lanao, Camp Keithley, *Clemens 621:* Davao Province, Catalogan, *Copeland 930;* Todaya, Mount Apo, *Copeland 1252:* Zamboanga Province, Sax River, *Williams 2144.* BASILAN, *Bur. Sci. 15456 Reillo.* JOLO, Mount Dajo, *Merrill 5330.* In damp forests at low and medium altitudes. Pantropic.

Local names: Balai (Bon.); bayag-bayág (C.Bis.); dijarán (Ig.); gumba (Sol.); kamámba (Tag.); kubámba (Tag.); kubánbang-damó (Tag.); kúyo (Bag.); kúyok (Bag.); pugápong (Buk.); tobayág (P.Bis.).

This is the only species of *Piper* in the Philippines with umbellate spikes. I agree with C. de Candolle in calling the Philippine form var. *subpeltatum.* It is characterized among the Philippine pipers by its erect habit, never scandent, its very large thin leaves, and numerous umbellately arranged spikes.

Section EUPIPER

C. DC. in Prodr. 16^1 (1869) 339, Candollea 1 (1923) 176.

Leaves of various form, nerved, plinerved or penninerved, base acute to cordate or peltate. Spikes solitary, leaf-opposed, greatly elongated, cylindric and slender to globose-ovoid, or long and interrupted. Flowers unisexual, diœcious, rarely bisexual.

Bracts free, pedicellate or sessile, peltate, or adnate to the rachis with margin and apex free. Fruits free, crowded to very loosely disposed, sessile or pedicellate or embedded in pulp. Stamens 2 or 3. Stigmas usually 3 or 4, rarely 5 or 6.

2. PIPER ARBORESCENS Roxb. Text fig. 2; Plate 17, fig. 5.

Piper arborescens ROXB. in Hort. Beng. (1814) 80, Fl. Ind. 1 (1820) 161, ed. 2, 1 (1832) 159; C. DC., Prodr. 16[1] (1869) 358; MERR., Interpret. Herb. Amb. (1917) 180, Enum. Philip. Fl. Pl. 2 (1923) 3.

Piper miniatum BLUME in Verh. Bat. Genoots. 11 (1826) 166; C. DC. Prodr. 16[1] (1869) 354, Leafl. Philip. Bot. 3 (1910) 766, Philip. Journ. Sci. 5 (1910) Bot. 422 (incl. formae *b, c,* and var. *hirtellum* C. DC.), 11 (1916) Bot. 208, Candollea 1 (1923) 181; F.-VILL., Novis. App. (1880) 175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219.

Piper glandulosum OPIZ in Presl Rel. Haenk. 1 (1828) 158.

Chavica miniata MIQ., Syst. Pip. (1843) 234, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 32, *t. 28,* Fl. Ind. Bat. 1[2] (1858–59) 440.

A diœcious vine; the branches glabrous, smooth, terete, canaliculate, pale to black, 1.5 to 3 mm in diameter. Leaves chartaceous to subcoriaceous, ovate-lanceolate to oblong-ovate, 11 to 22.5 cm long, 3.5 to 8.5 cm wide, glabrous on both surfaces, base equilaterally to subequilaterally subacute to rounded, usually with one minute auricle or lobule, 5- to 7-nerved, apex acutely acuminate to long and acutely acuminate, reticulations prominent; petioles glabrous to slightly puberulent, rugose, 2.5 to 10 mm long, in the lower leaves up to 15 mm long. Pistillate spikes greatly elongated, cylindric and slender, pendulous, 9.5 to 27.5 cm long, 3 to 7 mm in diameter; the peduncles glabrous, 2.5 to 7 cm long; rachis hirsute; bracts long-pedicellate, peltate, 1.2 to 1.8 mm long, disk orbicular, glabrous above and on the margin, 0.5 to 0.8 mm wide, pedicel 1 to 1.2 mm long, fleshy, hirsute; fruits free, crowded, sessile, oblong to oblong-ovoid, angular, 1.8 to 2 mm long, 0.6 to 0.8 mm in diameter, apex subacute to obtuse, glabrous, stigmas 3 or 4, sessile, apical; seeds oblong to oblong-ovoid, mucronate, 1.2 to 1.5 mm long, 0.5 to 0.6 mm in diameter. Staminate spikes pendulous, 15.5 to 24.5 cm long, 2 to 2.5 mm in diameter; the peduncles glabrous, 2 to 4.5 cm long; rachis hirsute; bracts subsessile to sessile, peltate, disk orbicular to suborbicular, glabrous above and on the margin, 0.6 to 0.9 mm wide; stamens 2 or 3, subpedicellate, about 0.5 mm long, anthers reniform, tetralocular, 2-valved, filaments slightly longer than the anthers.

LUZON, Abra Province, Mount Paraga, *Bur. Sci. 7205 Ramos:* Apayao Subprovince, Ngagan, *Bur. Sci. 28116 Fénix:* Rizal

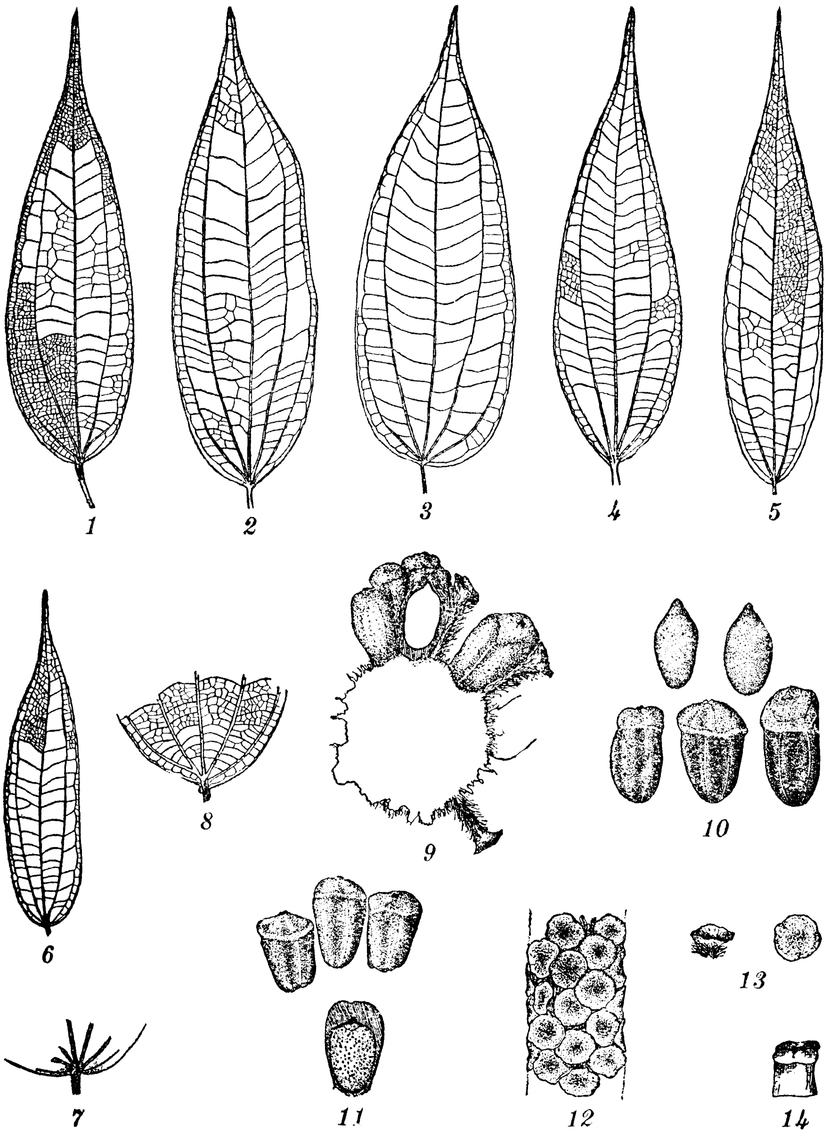


FIG. 2. *Piper arborescens* Roxb.; *1–4*, leaves, × 0.5; *7*, leaf base, upper surface, × 0.5; *8*, leaf base, lower surface, × 0.5; *9*, mature pistillate spike, transverse section, × 7.5; *10*, fruits and seeds, × 7.5; *12*, portion of mature staminate spike, × 5; *13*, side and top views of staminate bracts, × 7.5; *14*, stamen, × 15; var. *angustilimbum* var. nov.; *5–6*, leaves, × 0.5; *11*, fruits, × 7.5.

Province, Montalban, *Loher 12177:* Laguna Province, San Antonio, *Bur. Sci. 12018 Ramos;* Los Baños, Mount Maquiling, *Elmer 17532, 18027:* Tayabas Province, without definite locality, *Vidal 510:* Albay Province, without definite locality, *Cuming*

841: without definite locality, *Haenke s. n.* (type of *Piper glandulosum* Opiz in herb. Prague). MINDORO, Pinamalayan, *Bur. Sci. 40817 Ramos.* SAMAR, without definite locality, Cuming *1708;* Loquilocon, *Bur. Sci. 43775, 43786, 43878 McGregor;* Cauayan, *Bur. Sci. 17526 Ramos.* LEYTE, Jaro, Buenavista, *Wenzel 866, 721;* Tacloban, *Wenzel 1733.* PANAY, Capiz Province, Mount Madiaas, *Bur. Sci. 30629 Ramos and Edaño;* Jamindan, *Bur. Sci. 31065, 31080, 31166, 31365 Ramos and Edaño;* Agsaman, *Bur. Sci. 46098 Edaño.* MINDANAO, Surigao Province, Placer, *Wenzel 2902, 3212:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13378, 13661:* Bukidnon Province, Sumilao, *Bur. Sci. 15747 Fénix;* Mount Candoon, *Bur. Sci. 33826 Ramos and Edaño;* Tangkulan, Agusan River, *Bur. Sci. 39132 Ramos and Edaño;* Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n.* Common in forests at low and medium altitudes, ascending to 1,000 meters. Malay Peninsula and Archipelago.

Local names: Lauiñgan (Buk.); manlakbayan (Mbo.); opoi (Mbo.); parong (S.L.Bis.).

Merrill's reduction of *Piper miniatum* Blume to a synonym of *Piper arborescens* Roxb. is correct. The Rumphian illustration is decidedly out of proportion, the leaves and spikes being reduced; the description is good. This illustration is the whole basis of *Piper arborescens* Roxb. as originally published in Hortus Bengalensis (1814) 80.[4] The species was later described by Roxburgh from specimens collected in the Moluccas, the reference to Rumphius being included in the description. The original description applies to the above specimens in all respects. C. de Candolle later referred specimens collected in Borneo, Java, and Ceylon to *Piper arborescens* Roxb., apparently basing his description on this material. The actual Amboina specimens collected by Robinson were identified by C. de Candolle as *Piper miniatum* Blume which is a synonym of *Piper arborescens* Roxb.

This species is strongly characterized by its greatly elongated, cylindric, and slender pistillate spikes, its prominently nerved leaves and the presence of a minute auricle or lobule at the base of the lamina.

Var. ANGUSTILIMBUM var. nov.

Foliis anguste oblongo-lanceolatis ad elliptico-lanceolatis, apice attenuatis, acutis.

[4] See C. B. Robinson in Philip. Journ. Sci. 7 (1912) Bot. 415.

Branches glabrous, smooth. Leaves chartaceous, narrowly oblong-lanceolate to lanceolate-elliptic, 7 to 17 cm long, 1.5 to 4.5 cm wide, glabrous on both surfaces, base equilaterally to subequilaterally subacute to acute, apex acutely attenuate. Pistillate spikes sometimes as much as 8 cm long; pistillate bracts 1.2 to 1.5 mm long, disk 0.5 to 0.7 mm wide.

LUZON, Ilocos Norte, Bangui to Claveria, Mount Calvario, *Bur. Sci. 33050 Ramos:* Rizal Province, without definite locality, *Loher 14419;* Mount Lumutan, *Bur. Sci. 29671 Ramos and Edaño:* Laguna Province, San Antonio, *Bur. Sci. 14988 Ramos:* Tayabas Province, Lucban, *Elmer 7384* (type in herb. Manila), *7910:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16142.* SAMAR, Amabalate, *Bur. Sci. 17586 Ramos;* Catubig River, Pinipisakan, *Bur. Sci. 24330 Ramos.* LEYTE, Dagami, *Bur. Sci. 15256 Ramos;* Jaro, Buenavista, *Wenzel 914.* PANAY, Capiz Province, Mount Salibongbong, *Bur. Sci. 35620 Martelino and Edaño;* Mount Bulilao, *Bur. Sci. 35688, 35723, 35736, 35737, 35745, 35751, 35761 Martelino and Edaño.* MINDANAO, Zamboanga Province, Sax River, *Merrill 8106.* In forests at low and medium altitudes, ascending to 1,000 meters.

This variety differs from the species by its narrowly oblong-lanceolate to lanceolate-elliptic leaves.

Var. HIRTELLUM (Miq.) Merr.

Piper arborescens Roxb. var. *hirtellum* (Miq.) MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

Piper miniatum Blume var. *hirtellum* C. DC. in Leafl. Philip. Bot. 3 (1910) 776, Philip. Journ. Sci. 5 (1910) Bot. 422, Candollea 1 (1923) 261.

Chavica miniata Miq. var. *hirtella* MIQ., Fl. Ind. Bat. Suppl. (1860–61) 473.

Branches and petioles hirsute. Leaves glabrous above, hirsute on the nerves beneath. Peduncles glabrous to sparingly hirsute.

LUZON, Bataan Province, Mount Mariveles, near Camp Borden, *Leiberg 6077;* Mount Mariveles, *Elmer 6683;* Lamao River, Mount Mariveles, *Whitford 504:* Laguna Province, San Antonio, *Bur. Sci. 21974 Ramos:* Tayabas Province, hills near Malinao, *Baker 3250;* Casiguran, Mamatoc River, *Bur. Sci. 45542 Ramos and Edaño;* Mount Binuang, *Bur. Sci. 28753 Ramos and Edaño:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 15869.* SAMAR, Catbalogan, *Bur. Sci. 17439, 17575 Ramos;* Paranas, *Bur. Sci. 17645 Ramos;* Mount Capotoan, Catubig River, *Bur.*

Sci. 24310 Ramos; Las Naras, Catubig River, *Bur. Sci. 24521 Ramos.* LEYTE, Dagami, Panda, *Wenzel 352;* Tigbao, *Wenzel 1461;* Tacloban, *Wenzel 1705, 1743.* MINDANAO, Davao Province, Todaya, Mount Apo, *Elmer 11229:* Zamboanga Province, Malangas, *Bur. Sci. 34342 Ramos and Edaño.* BASILAN, *Bur. Sci. 15466 Reillo.* In forests at low and medium altitudes, ascending to 750 meters. Sumatra.

Local names: Mangolas (Sub.); parong (S.L.Bis.).

This variety differs from the species by its pubescent branches, petioles, and leaves.

3. **PIPER TRICHOPHLEBIUM** sp. nov. Text fig. 3; Plate 1.

Frutex dioicus, scandens; ramulis 2 ad 3 mm diametro; foliis breviter petiolatis, chartaceis, ellipticis ad oblongo-ovatis, 10.5 ad 14 cm longis, 5 ad 7.2 cm latis, basi aequilateralibus ad subaequilateralibus subacutis ad rotundatis, 5-nerviis, apice brevissime obtuse acuminatis, supra glabris, subtus ad nervo dense pilosis; spicis ♀ gracilis, 15 ad 18 cm longis, 4 mm diametro; rachis pilosis; pedunculis 3 ad 3.5 cm longis, pilosis; bracteis longe pedicellatis, peltatis, 1.2 ad 1.4 mm longis, peltis, suborbicularis, supra marginibusque glabris, 0.5 mm latis, pedicillis longe pilosis; baccis oblongis, 4- vel 5-angulatis, 1 ad 1.6 mm longis, 0.6 ad 0.8 mm diametro; stigmatibus 3 vel 4.

A diœcious vine; the branches pilose, terete, shallowly canaliculate, pale brown when dry, 2 to 3 mm in diameter. Leaves chartaceous, elliptic to oblong-ovate, 10.5 to 14 cm long, 5 to 7.2 cm wide, base equilaterally to subequilaterally subacute to rounded, 5-nerved, apex shortly and obtusely acuminate, glabrous above, densely pilose on the nerves beneath, margin glabrous, reticulations rather prominent beneath; petioles short, 4 to 5 mm long, the lower ones 10 to 12 mm long, densely pilose. Pistillate spikes greatly elongated, cylindric and slender, pendulous, 15 to 18 cm long, about 4 mm in diameter; the peduncles much longer than the petioles, sparsely pilose, 3 to 3.5 cm long; rachis pilose; bracts long-pedicellate, peltate, 1.2 to 1.4 mm long, disk suborbicular, denticulate, glabrous above and on the margin, about 0.5 mm wide, pedicel long, pilose; fruits free, crowded, oblong, 1 to 1.6 mm long, 0.6 to 0.8 mm in diameter, somewhat 4- or 5-angled; stigmas 3 or 4, appressed on the apex of the fruit, acute or obscurely coalescing into one at the maturity of the fruits.

PALAWAN, Binaloan, *Merrill 9404*, May 19, 1913 (type in herb. Manila), in forests at low altitudes.

This species is closely related to *Piper arborescens* Roxb. var. *hirtellum* (Miq.) Merr. from which it is distinguished by its elliptic to oblong-ovate leaves, which are shortly and obtusely acuminate and its oblong, somewhat 4- or 5-angled fruits.

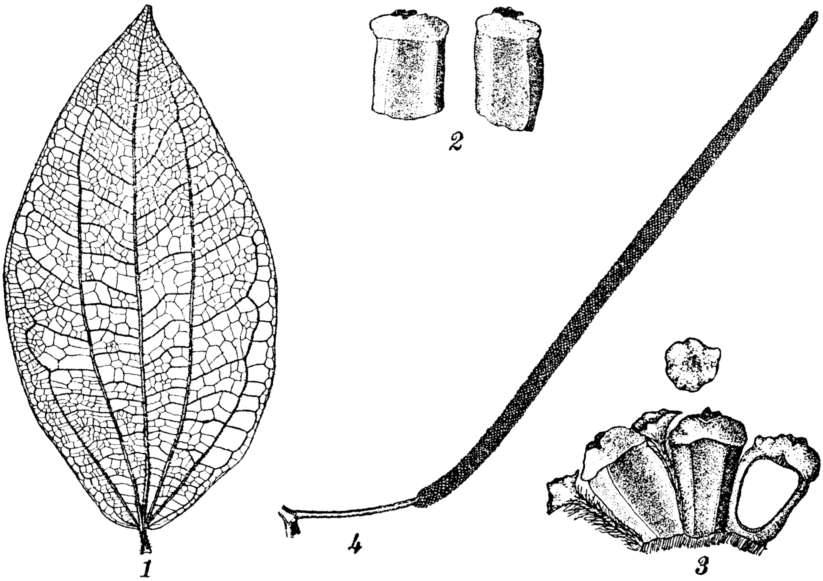


FIG. 3. *Piper trichophlebium* sp. nov.; *1*, leaf, × 0.5; *2*, fruits, × 10; *3*, portion of the transverse section of mature pistillate spike, × 10; *4*, mature pistillate spike, × 0.5.

4. PIPER PILIPES C. DC. Text fig. 4.

Piper pilipes C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 423, 11 (1916) Bot. 209, Candollea 1 (1923) 269; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

A diœcious vine; the branches villose, terete, brown when dry, 1.5 to 2.5 mm in diameter. Leaves chartaceous, oblong, oblong-ovate to oblong-elliptic, 11 to 15 cm long, 3 to 7 cm wide, base equilaterally subacute to rounded, 5-nerved, apex acutely acuminate to slenderly acutely acuminate, villose on both surfaces, reticulations prominent beneath; petioles short, densely villose, 5 to 7 mm long, in the lower leaves up to 15 mm long. Pistillate spikes greatly elongated, cylindric and slender, pendulous, 12 to 14 cm long, 4 to 6 mm in diameter; the peduncles much longer than the petioles, densely villose, 2.5 to 4 cm long; rachis

hirsute; bracts long-pedicellate, peltate, 1.2 to 1.4 mm long, disk suborbicular, glabrous above and on the margin, margin undulate, about 0.5 mm wide, pedicel long, hirsute; fruits free, crowded, oblong-obovoid, glabrous, apex truncate to rounded, about 1.5 mm long, 0.6 to 0.75 mm in diameter; stigmas 3, minute, sessile, apical.

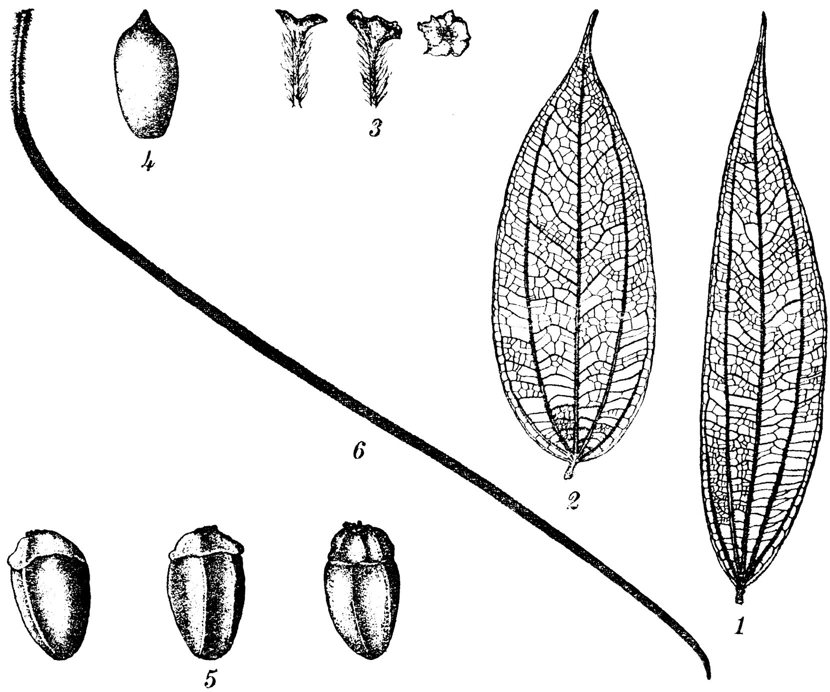


FIG. 4. *Piper pilipes* C. DC.; *1–2*, leaves, × 0.5; *3*, side and top views of bracts, × 10; *4*, seed, × 10; *5*, fruits, × 10; *6*, mature pistillate spike, × 0.5.

POLILLO, Polillo, *Bur. Sci. 6914 Robinson.* LEYTE, Jaro, Buenavista, *Wenzel 717, 894, 948.* MINDANAO, Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n.* (type collection): Davao Province, Mount Mayo, *Bur. Sci. 49472 Ramos and Edaño.* In forests at low and medium altitudes, ascending to 700 meters. Endemic.

A species manifestly allied to *Piper arborescens* Roxb. but recognized by its brown villose leaves, petioles, and peduncles and the long stiff hairs on the pedicel of the bracts.

5. **PIPER BREVICUSPE (Miq.) Merr. Text fig. 5.**

Piper brevicuspe (Miq.) MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.
Rhyncholepis brevicuspis MIQ., Syst. Pip. (1843) 283, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 46, *t. 45*, Fl. Ind. Bat. 1^2 (1858–59) 447.

Piper rhyncholepis C. DC., Prodr. 16[1] (1869) 344 (*rhyncholepsis*), Philip. Journ. Sci. 5 (1910) Bot. 423, 11 (1916) Bot. 209, Candollea 1 (1923) 212; F.-VILL., Novis. App. (1880) 176; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 220.

Piper rhyncholepis C. DC. var. *brevicuspe* C. DC., Prodr. 16[1] (1869) 344; Philip. Journ. Sci. 5 (1910) Bot. 424.

Rhyncholepis cumingiana MIQ., Syst. Pip. (1843) 282, non *Piper cumingiana* Miq., Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 45, *t. 45*.

A diœcious vine; the branches terete, hirsute, 1.5 to 4 mm in diameter. Leaves membranaceous, lower ones chartaceous, oblong to oblong-ovate, 11 to 21.5 cm long, 4.5 to 11.5 cm wide, base cordate-auriculate, lobes sometimes overlapping, equilaterally to subequilaterally rounded, 9- to 11-nerved, apex shortly and acutely acuminate to acutely acuminate, pilose on both surfaces, margin pilose, nerves rather prominent beneath, reticulations somewhat obscure above, rather prominent beneath; petioles hirsute, 5 to 10 mm long; stipules persistent, castaneo-hirsute, oblong-ovate, acuminate, 15 to 35 mm long, 3 to 6 mm wide, ventricose-concave, subcoriaceous. Pistillate spikes oblong, 2.5 to 7.5 cm long, 0.7 to 1 cm in diameter; the peduncles hirsute, 7 to 13 mm long, rarely up to 25 mm long; rachis hirsute; bracts pedicellate, peltate, disk orbicular, 0.6 to 0.8 mm wide, apex subulate, fleshy, angled, glabrous above; styles crowded, 1 to 2 mm long; stigmas 2 or 3, recurved, hispid, 0.5 to 0.8 mm long; fruits free, crowded, base concrescent, oblong to oblong-ovoid, 1 to 2 mm long, without the styles. Staminate spikes slender, 3.5 to 4 cm long, 2 to 3 mm in diameter; the peduncles hirsute, 0.5 to 0.7 cm long; rachis hirsute; bracts pedicellate, peltate, dense, imbricate, disk oblong to orbicular, angled, glabrous above and on the margin, margin membranaceous, apex subulate, pedicel hirsute; stamens 2, pedicellate, anthers oblong, bilocular, 2-valved, filaments 2 to 4 mm long.

SAMAR, without definite locality, *Cuming 1697* (type collection of *Rhyncholepis cumingiana* Miq. = *Piper rhyncholepis* C. DC.), *1706;* without definite locality, *Bur. Sci. 17409 Ramos;* Yaborog, *Bur. Sci. 17563 Ramos;* Paranas, *Bur. Sci. 17595 Ramos;* Loquilocon, *Bur. Sci. 43734 McGregor*. LEYTE, Tingib, *Philip. Pl. 1159 Ramos;* Dagami, Panda, *Wenzel 20, 21, 56;* Jaro, Buenavista, *Wenzel 733*. BOHOL, without definite locality, *Cuming 1843* (type collection of *Rhyncholepis brevicuspis* Miq.); Valencia, *Bur. Sci. 42824 Ramos;* Calingohan, *Bur. Sci. 43377 Ramos*. MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34455, 34532, 34804, 34815 Ramos and Pascasio;* Placer, *Wenzel 2871:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer*

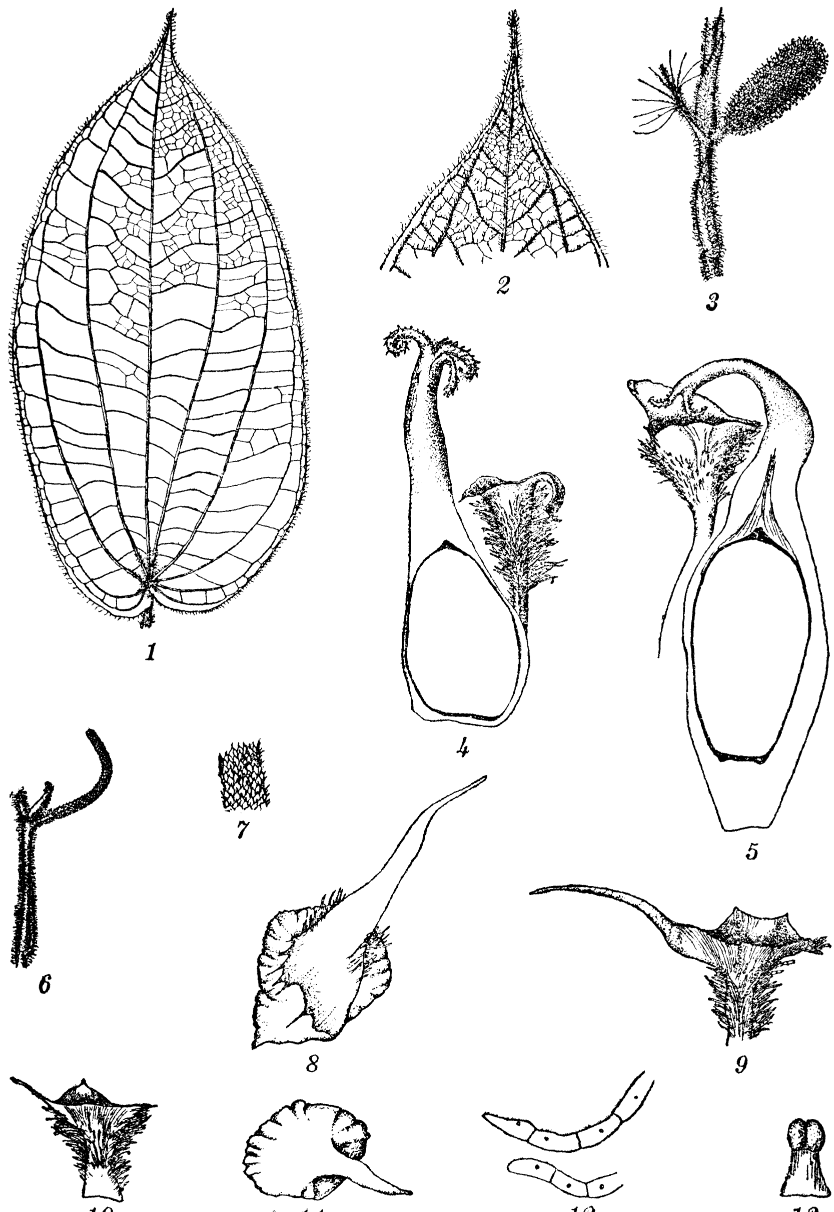


FIG. 5. *Piper brevicuspe* (Miq.) Merr.; *1*, leaf, × 0.5; *2*, apex of a leaf, × 0.5; *3*, mature pistillate spike and stipules, × 0.5; *4*, longitudinal section of a fruit, a bract and three stigmas, × 10; *5*, same with two stigmas, × 10; *6*, staminate spike, × 0.5; *7*, detail of a portion of 6 showing arrangement of bracts, about × 2; *8*, lower view of disk of ♀ bract, × 10; *9*, side view of disk of ♀ bract, × 10; *10*, side view of disk of ♂ bract, × 10; *11*, lower view of ♂ bract, × 10; *12*, hairs on bracts, much enlarged; *13*, stamen, × 10.

13410: Davao Province, Mount Mayo, *Bur. Sci. 49457, 49464 Ramos and Edaño.* In damp forests at low and medium altitudes. Endemic.

Local names: Talon-talón (Sub.); tonyabayán (Mbo.).

This species is distinguished from the rest of the Philippine pipers belonging to the auriculate group by its conspicuously nerved lamina. It is further characterized by its very unique bracts, the apex of the disk being subulate, the conspicuously pubescent surfaces of the lamina, and the long styles.

6. **PIPER MEDINILLIFOLIUM** sp. nov. Text fig. 6; Plate 2.

Frutex dioicus, scandens; ramulis dense villosis; foliis subchartaceis, oblongo-lanceolatis, 10 ad 14 cm longis, 2.3 ad 4.5 cm latis, basi aequiteralibus ad subaequilateralibus rotundatis, 7-plinerviis, apice acute acuminatis ad sat longe acute acuminatis, utrinque marginibusque hirsutis; spicis ♀ erectis, elon-

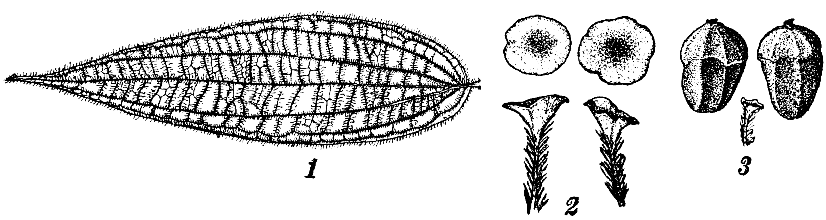


FIG. 6. *Piper medinillifolium* sp. nov.; *1*, leaf, × 0.5; *2*, top and side views of pistillate bracts, × 10; *3*, fruits and pistillate bract, × 7.5.

gatis, gracilis, 5 ad 5.5 cm longis, 3.5 ad 4.5 mm diametro; bracteis pedicellatis, peltatis, 1 ad 15 mm longis, peltis orbicularis, supra marginibusque glabris; baccis liberis, sessilibus, confertis, oblongo-subobovoideis, 1.75 ad 2 mm longis, 1 mm diametro; stigmatibus 3, ovoideis.

A diœcious vine; the branches densely villose, terete, minutely canaliculate, pale brown, 1.25 to 2.5 mm in diameter. Leaves subchartaceous, oblong-lanceolate, 10 to 14 cm long, 2.3 to 4.5 cm wide, base equilaterally to subequilaterally rounded, 7-plinerved, apex acutely acuminate to long and acutely acuminate, hirsute on both surfaces, margin prominently hirsute, reticulations more or less obscure above, prominent beneath; petioles short, densely villose, 3 to 5 mm long. Pistillate spikes elongated, cylindric, slender, erect, 5 to 5.5 cm long, 3.5 to 4.5 mm in diameter; the peduncles villose, very much longer than the petioles, 3.3 to 5 cm long; rachis hirsute; bracts long-pedicellate, peltate, 1 to 1.5 mm long, disk orbicular, about 0.75 mm wide,

glabrous above and on the margin, membranaceous, pedicels hirsute; fruits free, crowded, sessile, oblong-subobovoid, angled, 1.75 to 2 mm long, about 1 mm in diameter; stigmas 3, minute, ovoid, obtuse, sessile, apical.

LEYTE, Burauen, *Bur. Sci. 15364 Ramos* (type in herb. Manila), August 12, 1912, in the mossy forest; Jaro, Buenavista, *Wenzel 773, 893,* in forests, altitude about 500 meters.

A species manifestly belonging in the group with *Piper arborescens* Roxb. suggesting at first glance the Amboina species *Piper gelalae* C. DC. It is, however, by no means related to this. Its closest Philippine relative is *Piper pilipes* C. DC., from which it is distinguished by the conspicuous pubescence on the margin of the lamina, the plinerved venation of its leaves, and the comparatively shorter pistillate spikes.

7. **PIPER TOPPINGII C. DC.** Text fig. 7.

Piper toppingii C. DC. in Leafl. Philip. Bot. 3 (1910) 783, Philip. Journ. Sci. 5 (1910) Bot. 446, 11 (1916) Bot. 221, Candollea 1 (1923) 205; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper chlorocarpum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 221, Candollea 1 (1923) 241; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

A diœcious vine; the branches villose, terete, 2 to 3 mm in diameter. Leaves chartaceous, ovate-lanceolate to elliptic-lanceolate, 9 to 18 cm long, 2 to 8 cm wide, base subequilaterally subacute to subrounded, one lobe attenuate, the other narrowly rounded, to both rounded or both rarely acute, usually with a minute auricle or lobule at the base, attached to the petiole, 7-plinerved, apex acuminate to slenderly acuminate, acumen acute to subobtuse, glabrous above, hirsute to densely hirsute beneath, the younger leaves hirsute on both surfaces, very rarely hirsute on the midrib above or glabrous beneath, reticulations somewhat obscure above, prominent beneath; petioles densely hirsute, 3 to 8 mm long, in the lower leaves up to 13 mm long. Pistillate spikes greatly elongated, cylindric and slender, 7 to 13.2 cm long, 5 to 7 mm in diameter; the peduncles hirsute, 3 to 6.8 cm long; rachis densely hirsute; bracts long-pedicellate, peltate, 1.5 to 1.75 mm long, disk orbicular, glabrous above and on the margin, 0.75 to 1 mm wide, pedicels long, densely hirsute; fruits free, crowded, sessile, globose to obovoid, 1.75 to 2 mm long, 1 to 1.5 mm in diameter, somewhat angled; stigmas 3, minute, ovoid, sessile, apical. Staminate spikes subpendulous, slender, 6 to 11.5 cm long, 1 to 2.5 mm in diameter; the peduncles hirsute, 2.5 to 4.5 cm long; rachis densely hirsute;

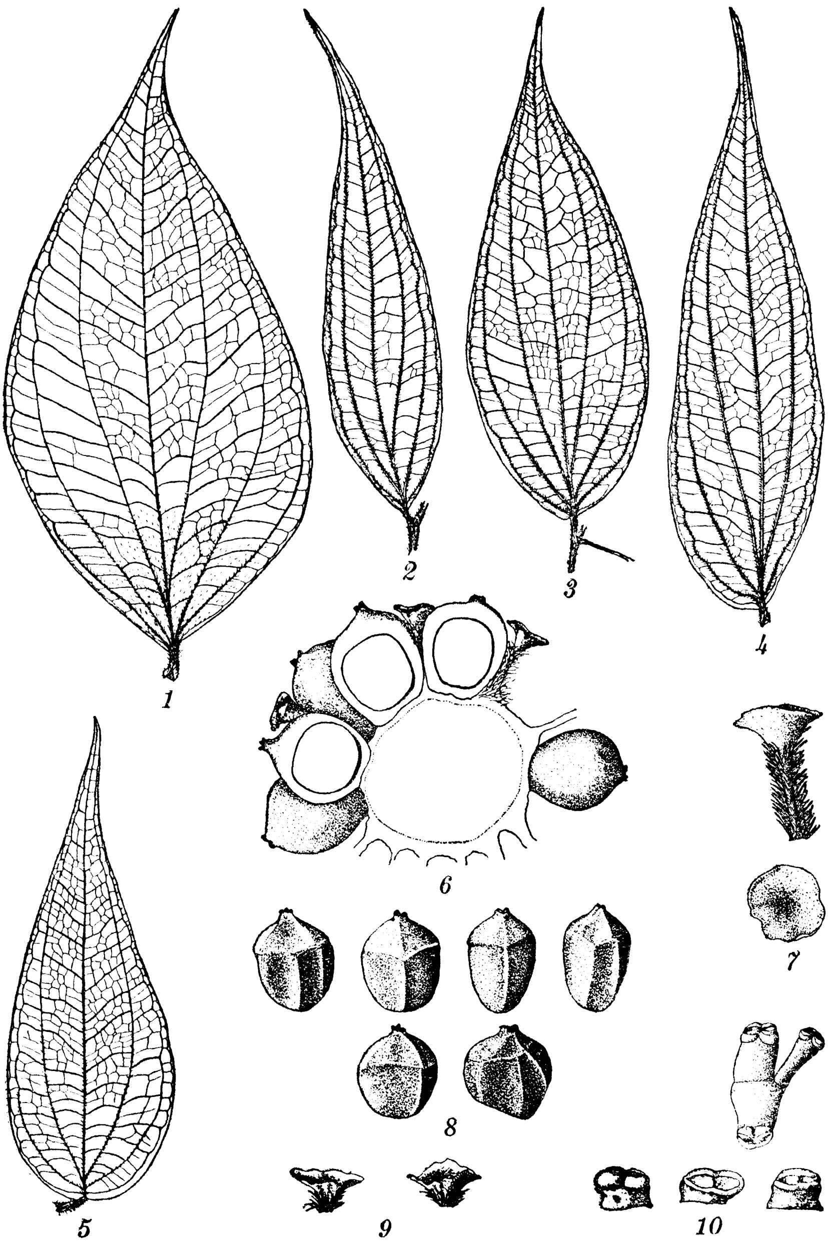


FIG. 7. *Piper toppingii* C. DC.; *1–5*, leaves, × 0.5; *6*, transverse section of mature pistillate spike, × 7.5; *7*, side and top views of pistillate bracts, × 10; *8*, fruits, × 7.5; *9*, side view of staminate bracts, × 10; *10*, stamens, × 10.

bracts somewhat pedicellate, peltate, 0.5 to 0.75 mm long, disk orbicular, glabrous above and on the margin, about 0.75 mm wide, pedicels densely hirsute, very slender; stamens 2 or 3, two lateral and one posterior, the latter usually smaller, somewhat pedicellate, 0.5 to 0.75 mm long, anthers oblong-ellipsoid bilocular, 2-valved, filaments oblong, stout, longer than the anthers.

LUZON, Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 33116 Ramos;* Mount Palimlim, *Bur. Sci. 33359 Ramos:* Bontoc Subprovince, without definite locality, *Vanoverbergh 691a;* Mount Puquis, *Bur. Sci. 37790 Ramos and Edaño;* Mount Polis, *Bur. Sci. 37650 Ramos and Edaño;* Mount Masapilid, *Bur. Sci. 37902 Ramos and Edaño:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19818 McGregor:* Benguet Subprovince, Mount Tonglon, *Merril 7770;* Baguio, *Elmer 8375* (type collection of *Piper toppingii* C. DC.), *5850, Williams 1091, For. Bur. 5081 Curran, Bur. Sci. 5555 Ramos, 14114 Robinson, Topping 14;* Mount Pulog, *Merrill 6530:* Nueva Viscaya Province, Compote, *Bur. Sci. 20129 McGregor:* Rizal Province, San Isidro, *Philip. Pl. 274 Ramos;* Mount Lumutan, *Bur. Sci. 29605, 29725, s. n. Ramos and Edaño;* Mount Susong-dalaga, *Bur. Sci. 29373 Ramos and Edaño:* Laguna Province, San Antonio, *Bur. Sci. 16638* (type collection of *Piper chlorocarpum* C. DC.) *20507 Ramos;* Mount San Cristobal, *Juliano 1080;* Mount Maquiling, *Baker 3499.* MINDORO, Mount Calavite, *Bur. Sci. 39396, 39473 Ramos:* Puluan, *Bur. Sci. 93787 Ramos.* In forests at medium and high altitudes, ascending to 2,100 meters. Endemic.

Local names: Duút (Ig.) ; litlít-matsing (Tag.).

A species clearly belonging in the group with *Piper arborescens* Roxb., being most closely allied to *Piper pilipes* C. DC., but differing essentially in its plinerved venation, ovate-lanceolate to elliptic-lanceolate leaves, and its relatively shorter pistillate spikes and bracts.

8. **PIPER URDANETANUM C. DC. Text fig. 8.**

Piper urdanetanum C. DC. in Leafl. Philip. Bot. 6 (1914) 2293, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper wenzelii C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 213, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper hirtirache C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 213, Candollea 1 (1923) 252; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

A diœcious vine; the branches glabrous, subterete, pale brown, canaliculate, 2.5 to 4 mm in diameter. Leaves chartaceous to subcoriaceous, elliptic-lanceolate to elliptic-ovate-lan-

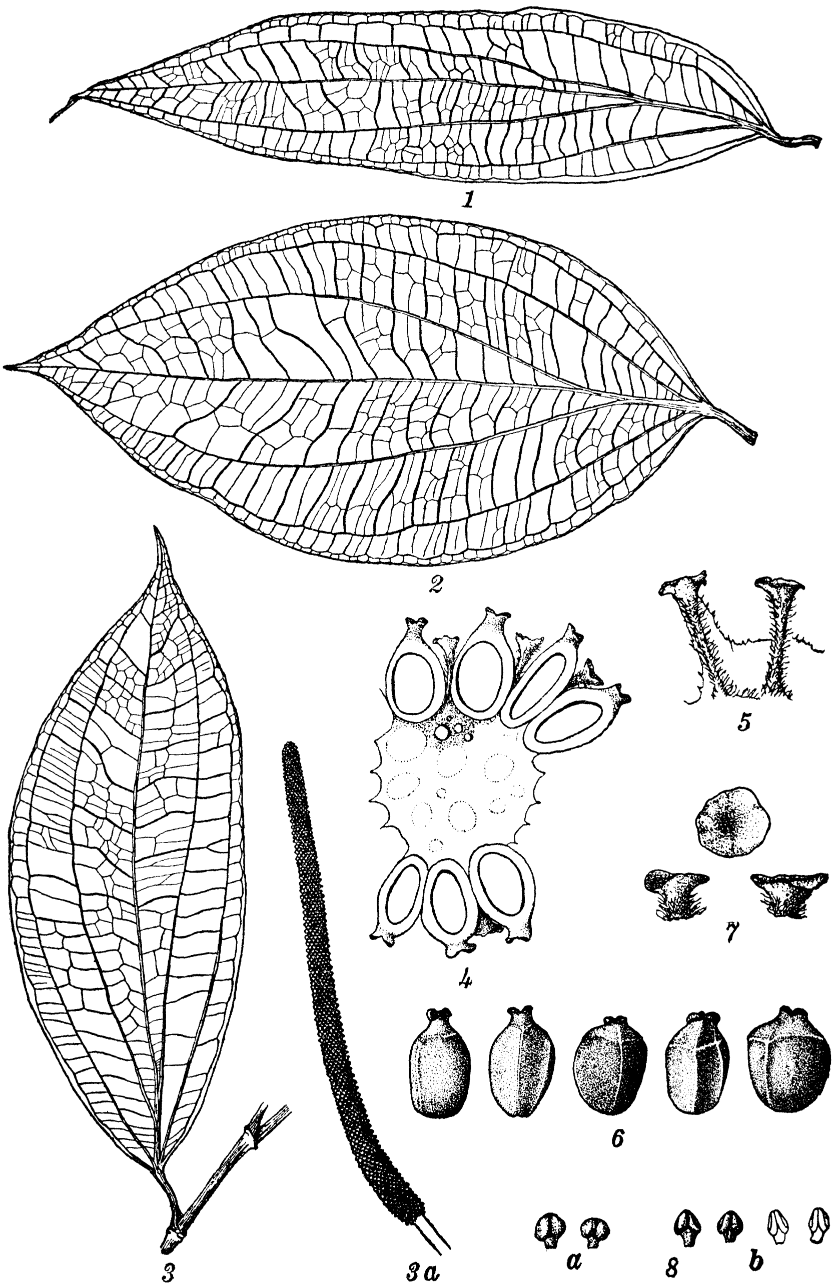


FIG. 8. *Piper urdanetanum* C. DC.; *1–3*, leaves, × 0.5; *3a*, mature pistillate spike, × 0.5; *4*, transverse section of mature pistillate spike, × 7.5; *5*, side view of pistillate bracts, × 10; *6*, fruits, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, *a*, before dehiscence, *b*, after dehiscence, × 10.

ceolate, 11 to 23 cm long, 3.5 to 9.3 cm wide, base equilaterally acute, 7-plinerved, apex acutely acuminate to long and acutely acuminate, glabrous on both surfaces, reticulations somewhat prominent on both surfaces; petioles glabrous, 10 to 20 mm long. Pistillate spikes greatly elongated, cylindric and slender, 7 to 21.5 cm long, 4 to 7 mm in diameter; the peduncles glabrous, 1.7 to 3.3 cm long; rachis densely hirsute; bracts long-pedicellate, peltate, 1.5 to 2 mm long, disk orbicular, glabrous, 0.5 to 0.75 mm wide, pedicels long, densely hirsute; fruits free, sessile, crowded, glabrous, oblong to oblong-subobovoid, 1.75 to 2 mm long, 0.8 to 1.25 mm in diameter; stigmas 3, rarely 4, short, ovoid, acute, sessile, apical. Staminate spikes 6 to 11.5 cm long, 1.75 to 2 mm in diameter; the peduncles glabrous, 10 to 20 mm long; rachis densely hirsute; bracts pedicellate, peltate, subimbricate, 0.5 to 0.6 mm long, disk orbicular, glabrous, subfleshy, 0.75 to 0.8 mm wide, pedicels stout, densely hirsute; stamens 2, somewhat pedicellate, 0.3 to 0.5 mm long, anthers ovoid to globose-ovoid, bilocular, 2-valved, filaments very slender, shorter than the anthers.

SAMAR, Ambalate, *Bur. Sci. 17587 Ramos;* Catubig River, *Bur. Sci. 24165, 24285 Ramos.* LEYTE, Jaro, Buenavista, *Wenzel 628* (type collection of *Piper wenzelii* C. DC.), *723, 779, 819, 891, 1197, 1168* (type collection of *Piper hirtirache* C. DC.). MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13713* (type collection of *Piper urdanetanum* C. DC.). In forests at low and medium altitudes, ascending to 500 meters. Endemic.

Local name: Sauodan (Mbo.).

A species belonging in the group with *Piper arborescens* Roxb., but by its slender pistillate spikes being nearer to *Piper toppingii* C. DC. It differs from the latter in the absence of small auricles or lobules at the base of the lamina, and its glabrous leaves, branches, and peduncles.

9. PIPER SIMILE sp. nov. Text fig. 9; Plates 3 and 4.

Frutex dioicus, scandens; ramulis glabris; foliis chartaceis ad subcoriaceis, elliptico-lanceolatis, 7.5 ad 11.8 cm longis, 1.7 ad 3.3 cm latis, basi aequilateralibus acutis, 5-plinerviis, apice attenuate acutis, utrinque glabris; spicis ♀ gracilis, 4 ad 4.5 cm longis, 4.5 ad 5 mm diametro; bracteis pedicellatis, peltatis, peltis orbicularis, supra marginibusque glabris, crenulatis, leviter depressis; baccis liberis, confertis, sessilibus, oblongo-obovoideis ad obovoideis, 1.5 ad 1.75 mm longis, 1 ad 1.25 mm diametro;

stigmatibus 3 vel 4, rotundato-ovoideis, sessilibus; staminibus 2, subsessilibus, antheris reniformibus, 2-valvatis, bracteis sessilibus.

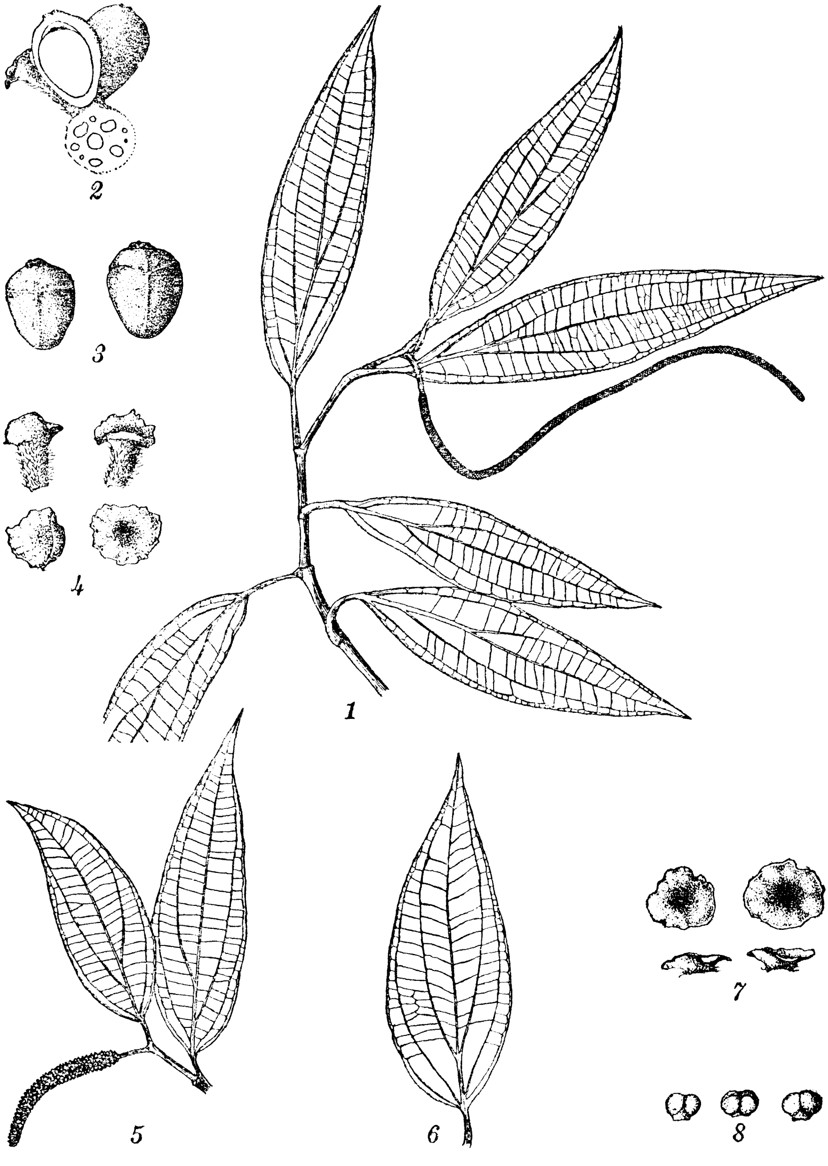


FIG. 9. *Piper simile* sp. nov.; *1*, habit, male plant, × 0.5; *2*, portion of the transverse section of a mature pistillate spike, × 7.5; *3*, fruits, × 7.5; *4*, side and top views of pistillate bracts, × 10; *5*, habit, female plant, × 0.5; *6*, leaf, × 0.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, × 10.

A diœcious vine; the branches glabrous, subterete, 1.75 to 4 mm in diameter. Leaves chartaceous to subcoriaceous, elliptic-lanceolate, 7.5 to 11.8 cm long, 1.7 to 3.3 cm wide, base equilaterally acute, 5-plinerved, apex acutely attenuate, entirely glabrous on both surfaces, reticulations somewhat obscure on both surfaces; petioles glabrous, 6 to 12 mm long, in the lower leaves up to 25 mm long. Pistillate spikes cylindric, slender, 4.5 to 5 cm long, 4.5 to 5 mm in diameter; the peduncles glabrous, 7 to 8 mm long; rachis densely hirsute; bracts pedicellate, peltate, about 1 mm long, disk orbicular, 0.6 to 0.75 mm wide, glabrous, membranaceous, crenulate, somewhat depressed, pedicels densely hirsute; fruits free, sessile, somewhat crowded, oblong-obovoid to obovoid, glabrous, 1.5 to 1.75 mm long, 1 to 1.25 mm in diameter; stigmas 3 or 4, short, rounded-ovoid, sessile, apical. Staminate spikes long and pendulous, slender, 9.5 to 14 cm long, 2 to 2.5 mm in diameter; the peduncles glabrous, 7 to 10 mm long; rachis densely hirsute; bracts sessile, peltate, disk orbicular, 0.6 to 0.75 mm wide, glabrous, membranaceous; stamens 2, subsessile, 0.25 to 0.3 mm long, anthers reniform, 2-valved.

LUZON, Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 33105 Ramos* (type in herb. Manila), August 11, 1918, at an altitude of about 500 meters: Tayabas Province, Mount Alzapan, *Bur. Sci. 45702 Ramos and Edaño,* June 6, 1925, on forested slopes, altitude about 1,900 meters.

A species closely allied to *Piper urdanetanum* C. DC., in vegetative characters approaching *Piper elliptibaccum* C. DC., but with pistillate spikes clearly approaching *Piper urdanetanum* C. DC., but differing from both species in many respects. It is distinguished from *Piper elliptibaccum* C. DC. by its slender pistillate spikes and from *Piper urdanetanum* C. DC. by the size and form of its leaves, its relatively shorter pistillate spikes, sessile staminate bracts, and subsessile stamens.

10. PIPER LESSERTIANUM (Miq.) C. DC. Text fig. 10.

Piper lessertianum (Miq.) C. DC., Journ. Bot. 4 (1866) 164;[6] MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

Chavica lessertiana MIQ., Syst. Pip. (1843) 270, Fl. Ind. Bat. 1^2 (1858–59) 445.

Piper pseudochavica C. DC., Prodr. 16^1 (1869) 351, Leafl. Philip. Bot. 3 (1910) 769, Philip. Journ. Sci. 5 (1910) Bot. 427, 11 (1916) Bot. 212, Candollea 1 (1923) 201; F.-VILL., Novis. App. (1880) 175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219.

[6] Non C. DC. Prodr. 16^1 (1869) 258, Candollea 1 (1923) 152.

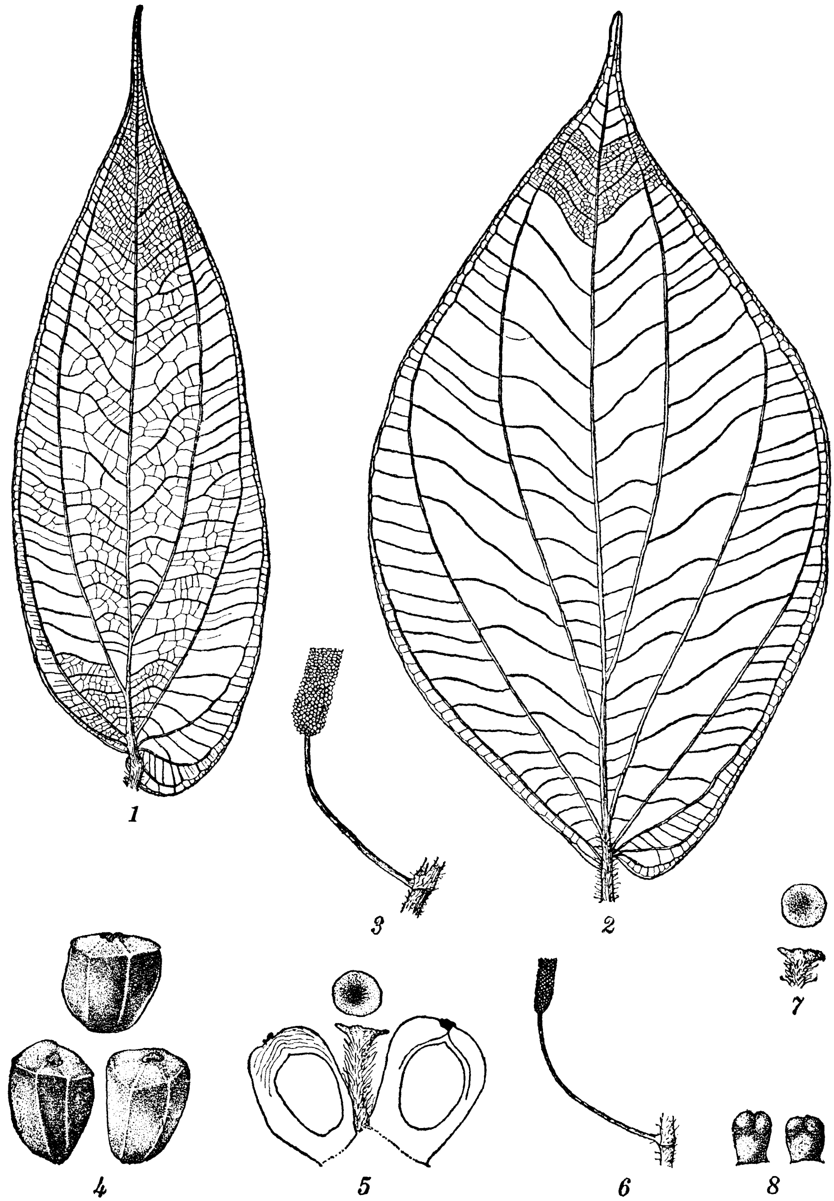


FIG. 10. *Piper lessertianum* (Miq.) C. DC.; *1–2*, leaves, × 0.5; *3*, portion of pistillate spike, × 0.5; *4*, fruits, × 7.5; *5*, longitudinal section of fruits and ♀ bracts, × 7.5; *6*, portion of staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamens, × 10.

A diœcious vine; the branches glabrous to villose, terete, 2 to 6 mm in diameter. Leaves chartaceous to subcoriaceous, broadly ovate-elliptic, oblong-elliptic or elliptic lanceolate, 12.5 to

32 cm long, 5.5 to 16.5 cm wide, base inequilaterally rounded, one lobe acute to narrowly rounded, the other auriculate, 7- to 9-plinerved, apex usually long and acutely acuminate, sometimes acutely acuminate, glabrous above, sparsely hirsute to villose on the nerves beneath, very rarely glabrous, reticulations somewhat obscure above, prominent beneath; petioles glabrous to villose, 2 to 6 mm long. Pistillate spikes elongated, cylindric and slender, 2.5 to 6 cm long, 5 to 10 mm in diameter; the peduncles 3 to 8 cm long, glabrous; rachis hirsute; bracts long-pedicellate, peltate, 2 to 2.2 mm long, disk suborbicular to orbicular, glabrous, 0.6 to 0.8 mm wide, pedicel hirsute; fruits free, crowded, oblong to oblong-ovoid, 1.8 to 2.3 mm. long, 1 to 1.5 mm. in diameter, angled; stigmas 3, rounded, sessile, apical; seeds oblong to oblong-ovoid, adhering to the pericarp, 1.5 to 2 mm long. Staminate spikes 2.5 to 4.5 cm long, 2 to 4 mm in diameter; the peduncles glabrous to sometimes sparsely hirsute, 3 to 6.5 cm long; rachis hirsute; bracts pedicellate, peltate, 0.5 to 0.75 mm long, disk imbricate, orbicular, glabrous, about 0.75 mm wide, pedicel hirsute; stamens 2, subsessile, 0.5 to 1 mm long, anthers oblong, tetralocular, 2-valved.

LUZON, Cagayan Province, without definite locality, *Cuming 1343* (type collection of *Chavica lessertiana* Miq.) : Apayao Subprovince, Guiniri, *Bur. Sci. 28226 Fénix:* Kalinga Subprovince, Mount Masingit, *Bur. Sci. 37606 Ramos and Edaño:* Bontoc Subprovince, Pininggat, *Vanoverbergh 691:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19823 McGregor:* Rizal Province, Montalban, *Loher 12941:* Tayabas Province, Mount Binuang, *Bur. Sci. 28688 Ramos and Edaño;* Mount Banahao, *Bur. Sci. 47415 McGregor;* Casiguran, *Bur. Sci. 45351 Ramos and Edaño.* ALABAT, *Bur. Sci. 48053, 48062, Ramos and Edaño.* MINDORO, without definite locality, *For Bur. 11411 Merritt;* Mount Calavite, *Bur. Sci. 39417, 39432 Ramos;* Mount Halcon, *Bur. Sci. 40639, 40676 Ramos and Edaño.* PANAY, Capiz Province, Mount Macosolon, *Bur. Sci 30776 Ramos and Edaño;* Jamindan, *Bur. Sci. 30834, 30861, 30916, 31263, 31272 31372 Ramos and Edaño;* Mount Salibongbong, *Bur. Sci. 35514 Martelino and Edaño;* Mount Kinablangan, *Bur. Sci. 46051, 46176 Edaño.* MINDANAO, Lanao Province, Lake Lanao, Camp Keithley, *Clemens 574;* Saguin-saguing, *For. Bur. 23384 Acuña:* Zamboanga Province, Malangas, *Bur. Sci. 36976 Ramos and Edaño.* BUCAS GRANDE, *Bur. Sci. 35118 Ramos and Pascasio.* In damp forests at medium altitudes. Endemic.

Local names: Amomoslo (Mang.) ; manikatápai (Bag.).

The alliance of this species is with *Piper toppingii* C. DC., from which it differs in its auriculate leaves, shorter staminate spikes, and other characters.

Var. OBLONGIBACCUM (C. DC.) comb. nov. Text fig. 11.

Piper oblongibaccum C. DC. in Leafl. Philip. Bot. 3 (1910) 777, Philip. Journ. Sci. 5 (1910) Bot. 441, Candollea 1 (1923) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

Piper pseudochavica C. DC. var. *angustilimbum* C. DC. in Candollea 1 (1923) 201.

Lamina narrowly elliptic-lanceolate, 2.5 to 6 cm wide, peduncles usually shorter than in the species.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28507 Ramos and Edaño:* Sorsogon Province, Irosin, Mount Bulusan,

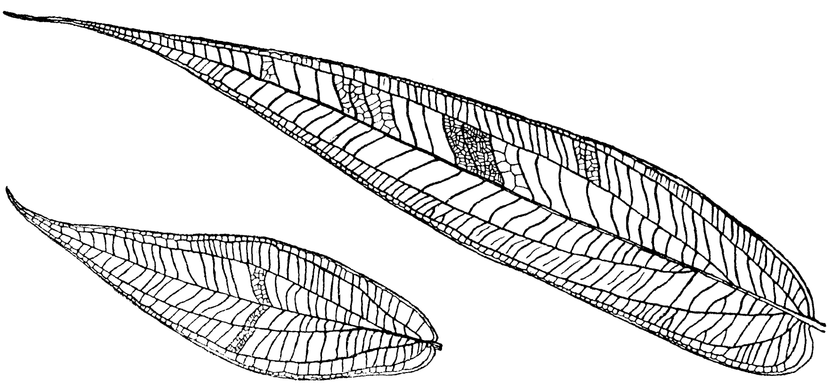


FIG. 11. *Piper lessertianum* (Miq.) C. DC. var. *oblongibaccum* (C. DC.) comb. nov.; leaves, × 0.5.

Elmer 16317. MINDORO, Mount Calavite, *Bur. Sci. 39443bis Ramos.* SAMAR, Las Navas, Catubig River, *Bur. Sci. 24527 Ramos.* PANAY, Capiz Province, Mount Macosolon, *Bur. Sci. 30787 Ramos and Edaño;* Libacao, *Bur. Sci. 35395, 35442 Martelino and Edaño.* NEGROS, Occidental Negros Province, Mount Canlaon, *For. Bur. 13679 Curran:* Oriental Negros Province, Dumaguete, Cuernos Mountains, *Elmer 9456* (type collection of *Piper oblongibaccum* C. DC.). MINDANAO, Bukidnon Province, Mahilucot River, *Bur. Sci. 38688 Ramos and Edaño:* Davao Province, Mount Apo, *Copeland 1140, Elmer 11417.* In damp forests at medium altitudes. Endemic.

Local names: Buyok-buyok (C. Bis.); tugpoai (Buk.).

This variety differs from the species in its narrowly elliptic-lanceolate leaves.

11. PIPER SUBPROSTRATUM C. DC. Text figs. 12 and 13.

Piper subprostratum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 425, Candollea 1 (1923) 202; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

A diœcious subprostrate shrub, 1 to 1.5 m high; the branches puberulent, angled, canaliculate, 5 to 10 mm in diameter. Leaves membranaceous, large, oblong-ovate to broadly ovate-elliptic, 18

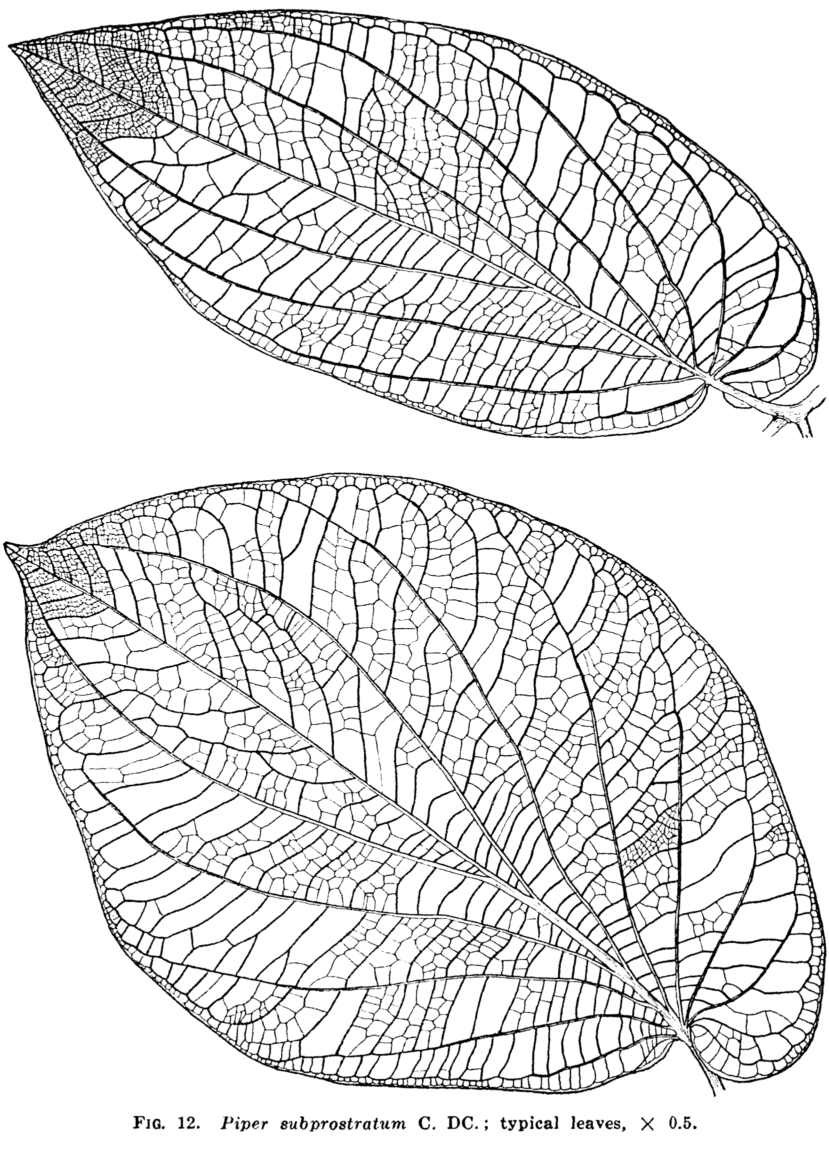


FIG. 12. *Piper subprostratum* C. DC.; typical leaves, × 0.5.

to 23 cm long, 10 to 13 cm wide in the male, 24 to 26 cm long and 15.5 to 16.5 cm wide in the female, base inequilaterally cordate, one lobe subrounded, the other auriculate, 11- to 13-plinerved, apex acutely attenuate to short and acutely acuminate, glabrous above, puberulent on the nerves beneath, reticulations somewhat prominent on both surfaces; petioles puberulent, 1.5 to 3.5 cm long. Pistillate spikes erect, cylindric, slender, 4 to 4.5 cm long, 6 to 7 mm in diameter; the peduncles puberulent, about 3.5 cm long; rachis slightly pilose; bracts long-pedicellate, peltate, disk suborbicular, about 1 mm wide, lobed, glabrous, pedicel 2 to 2.3 mm long, pilose; fruits free, not crowded, partly embedded in and concrescent with the rachis, glabrous, elliptic-obovoid, about 3 mm long, 1.5 to 1.8 mm in diameter; styles sessile; stigmas 3, sessile, apical, papillate; seeds oblong, adhering

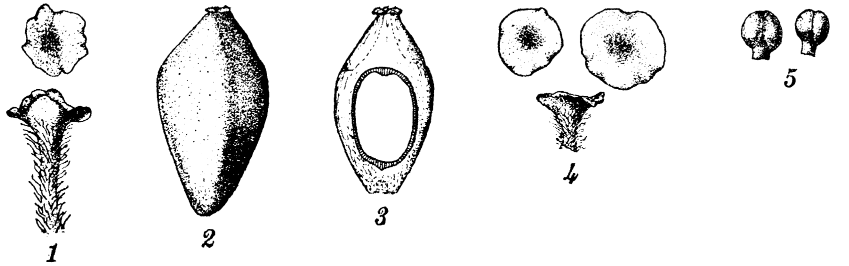


FIG. 13. *Piper subsprostratum* C. DC.; *1*, top and side views of pistillate bracts, × 7.5; *2*, fruit, × 7.5; *3*, longitudinal section of a fruit, × 7.5; *4*, top and side views of staminate bracts, × 7.5; *5*, stamens, × 7.5.

to the pericarp, about 2 mm long. Staminate spikes erect, 7.5 to 11.5 cm long, 4 to 5 mm in diameter; the peduncles puberulent, 3 to 3.5 cm long; rachis hirsute; bracts pedicellate, peltate, about 1 mm long, disk orbicular, glabrous, 1 to 1.5 mm wide, pedicel hirsute; stamens 2, about 0.8 mm long, anthers subglobose, bilocular, 2-valved, filaments shorter than the anthers.

LUZON, Rizal Province, Mount Lumutan, *Bur. Sci. 42222 Ramos*. MINDORO, south of Lake Naujan, *For. Bur. 6751 Merritt* (type collection); Mount Halcon, *Bur. Sci. 40719, 40720, 40726, Ramos and Edaño*. In forests at low and medium altitudes. Endemic.

This species is allied to *Piper lessertianum* (Miq.) C. DC.; it differs in its habit, in the nature of the pubescence on the vegetative parts, in its fruits being partly embedded in the rachis, and in its subglobose anthers.

12. PIPER DECUMANUM Linn. Text fig. 14.

Piper decumanum LINN. in Stickman Herb. Amb. (1754) 19, Amoen. Acad. 4 (1759) 128, Sp. Pl. ed. 2 (1762) 41; MERR., Interpret. Herb. Amb. (1917) 181, Enum. Philip. Fl. Pl. 2 (1923) 7; C. DC., Candollea 1 (1923) 230.

Sirium decumanum RUMPH., Herb. Amb. 5: 45, *t. 27*.

Piper forstenii C. DC., Prodr. 16[1] (1869) 348, Leafl. Philip. Bot. 3 (1910) 768, Philip. Journ. Sci. 5 (1910) Bot. 424, Candollea 1 (1923) 190.

A diœcious vine; the branches glabrous, terete, rigid, pale when dry, 6 to 12 mm in diameter. Leaves subcoriaceous to coriaceous, broadly oblong-ovate to broadly ovate, 28 to 43 cm long, 11 to 25 cm wide, base inequilaterally cordate-auriculate, lobes rounded, 13- to 15-plinerved, apex acute to shortly and acutely acuminate, glabrous and shining on both surfaces, reticulations prominent on both surfaces; petioles glabrous, 4 to 7 cm long; stipules 3.5 to 4 cm long, with dark-red glandular dots. Pistillate spikes pendulous, greatly elongated, cylindric and slender, 25 to 30 cm long, 8 to 10 mm in diameter; the peduncles glabrous, 4.5 to 6 cm long; rachis hirsute; bracts long-pedicellate, peltate, 2.5 to 3 mm long, disk concave, suborbicular, 0.8 to 1 mm wide, glabrous, pedicel hirsute; fruits crowded, free, oblong-obovoid, 2.3 to 2.5 mm long, about 1.5 mm in diameter, when young angled, becoming terete when mature, reddish brown; stigmas fleshy, trilobed; seeds oblong-ovoid. Staminate spikes greatly elongated, slender, pendulous, 24.5 to 38 cm long, 4 to 5 mm in diameter; the peduncles 2.5 to 3.5 cm long, glabrous; rachis hirsute; bracts long-pedicellate, peltate, 1.2 to 1.5 mm long, disk rounded, glabrous, about 1 mm wide, pedicel hirsute, fleshy; stamens 2, pedicellate, about 1 mm long, anthers subglobose to globose, bilocular, 2-valved, filaments longer than the anthers.

LEYTE, Mount Cabalian, *Bur. Sci. 41513 Ramos*. MINDANAO, Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n., 572:* Bukidnon Province, Sumilao, *Bur. Sci. 15667 Fénix:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13296*. In forests at medium altitudes. Moluccas.

Local names: Barágit (Bag.); búyog (Mbo.); malapágba (Buk.).

This species is distinguished from all the species belonging to the auriculate group by its exceedingly long spikes and large leaves. Elmer's field note records the fact that the leaf attains a length of 90 centimeters.

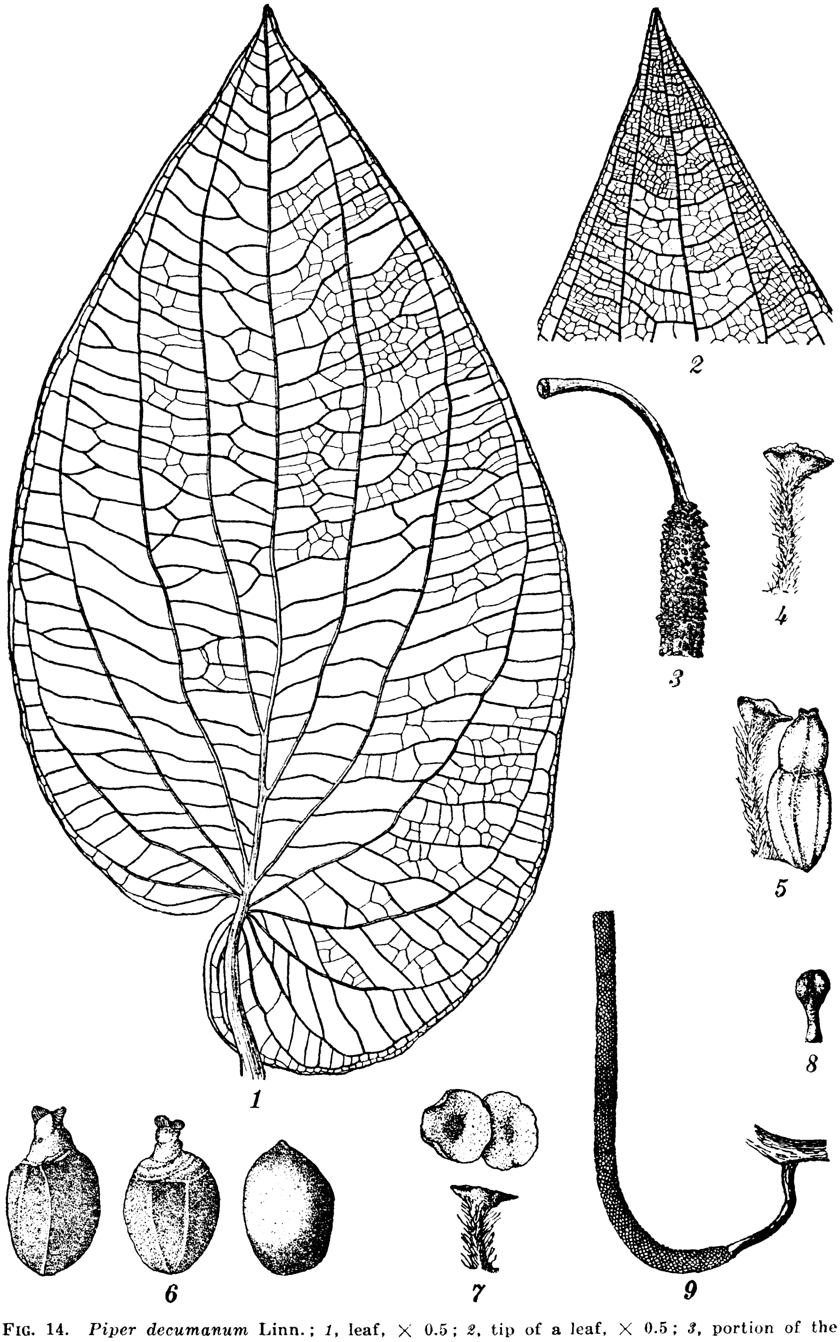


FIG. 14. *Piper decumanum* Linn.; *1*, leaf, × 0.5; *2*, tip of a leaf, × 0.5; *3*, portion of the pistillate spike, × 0.5; *4*, pistillate bract, × 7.5; *5*, young fruit and bract, × 7.5; *6*, fruits and seed, × 7.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamen, × 7.5; *9*, portion of staminate spike, × 0.5.

13. PIPER LAGENIOVARIUM C. DC. Text fig. 15.

Piper lageniovarium C. DC. in Leafl. Philip. Bot. 3 (1910) 767, Philip. Journ. Sci. 5 (1910) Bot. 424, Candollea 1 (1923) 201; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

Erect, suffrutescent, 3 to 5 m high; stem glabrous, terete, 7.5 to 13 cm in diameter; branches sparsely hirsute, the ultimate ones densely hirsute, 3 to 6 mm in diameter. Leaves membra-

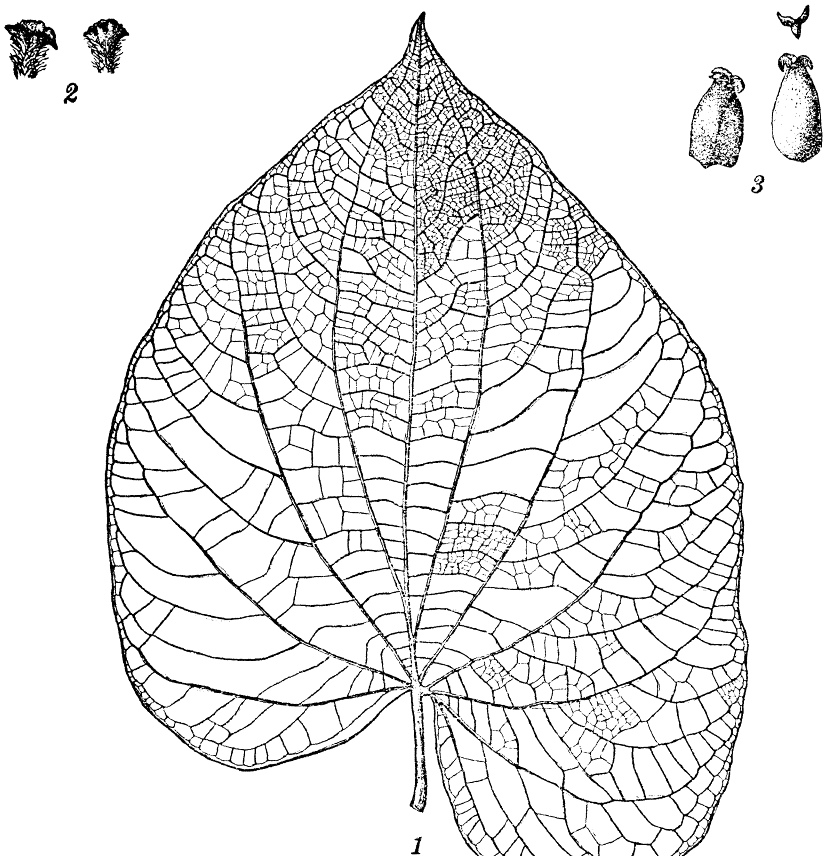


FIG. 15. *Piper lageniovarium* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bracts, × 7.5; *3*, ovaries and stigmas, × 7.5.

naceous to chartaceous, broadly ovate, 21.5 to 28.5 cm long, 15.5 to 19.5 cm wide, base inequilateral, broadly and deeply cordate, lobes rounded, sinuses up to 6.5 cm deep, 10-plinerved, apex shortly and acutely acuminate, glabrous above, minutely puberulent on the nerves beneath, reticulations prominent on both surfaces; petioles sparsely hirsute, 3 to 4.5 cm long; sti-

pules lanceolate, long and acutely acuminate, 7 to 10 cm long, glabrous, tubercular, black. Pistillate spikes pendulous, greatly elongated and slender, 19.5 to 22 cm long, 5 to 8 mm in diameter; the peduncles sparsely hirsute, 10 to 15 mm long; rachis villose; bracts pedicellate, peltate, 0.8 to 1 mm long, disk suborbicular, 0.5 to 0.8 mm wide, glabrous, fleshy, margin crenulate, somewhat compressed, pedicel villose; pistil 1.8 to 2 mm long, ovary free, glabrous, lageniform, sessile, style sessile, stigmas 3, sessile, apical, ovoid, acute, reflexed, glabrous.

MINDANAO Davao Province, Todaya, Mount Apo, *Elmer 10589* (type collection): Bukidnon Province, Kalasuñgay, *Wester 129*. In thickets and forests at medium altitudes. Endemic.

Local names: Kúyo (Bag.); pogápong (Buk.).

This species is closely allied to *Piper pergrande* C. DC. (*Piper grande* Ridley), of New Guinea, but has pubescent leaves, branches, petioles, and peduncles. Furthermore, the spikes of *Piper lageniovarium* C. DC. are pistillate. I find on examination of an isotype of *Piper pergrande* C. DC. (C. Boden Kloss, Camp I, Nov.-Dec., 1912) that the original description must be amended to read hermaphroditic instead of pistillate spikes.

14. PIPER MAJUSCULUM Blume. Text fig. 16.

Piper majusculum BLUME in Verh. Bat. Genoots. 11 (1826) 210, *f.* 25; C. DC., Prodr. 16[1] (1869) 350, Candollea 1 (1923) 191.

Chavica majuscula MIQ., Syst. Pip. (1843) 271.

Piper rotundistigmum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 425, 11 (1916) Bot. 209 (incl. var. *pilosius* C. DC.), Candollea 1 (1923) 201, 206; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

Piper leyteanum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 220, Candollea 1 (1923) 206.

A diœcious vine; stem less than 2.5 cm in diameter; the young branches pubescent, becoming glabrous in age, terete, 3 to 6 mm in diameter. Leaves chartaceous to subcoriaceous, firm when dry, large, oblong-ovate to ovate, 18.5 to 30.5 cm long, 7.5 to 16.5 cm wide, base equilaterally to inequilaterally cordate, one or both lobes auriculate, multipenninerved, apex acutely acuminate, glabrous above, usually hirsute on the nerves beneath, sometimes glabrous, reticulations somewhat obscure above, prominent beneath; petioles 1.5 to 3.5 cm long, usually hirsute, rarely glabrous; stipules lanceolate, 4.5 to 6 cm long 5 to 6 mm wide, glabrous or hirsute. Pistillate spikes greatly elongated, cylindric and slender, pendulous, 26 to 32 cm long, 6 to 8 mm in diameter; the peduncles glabrous or hirsute, 4.5 to 7 cm long; rachis glabrous to sparsely hirsute; bracts subsessile,

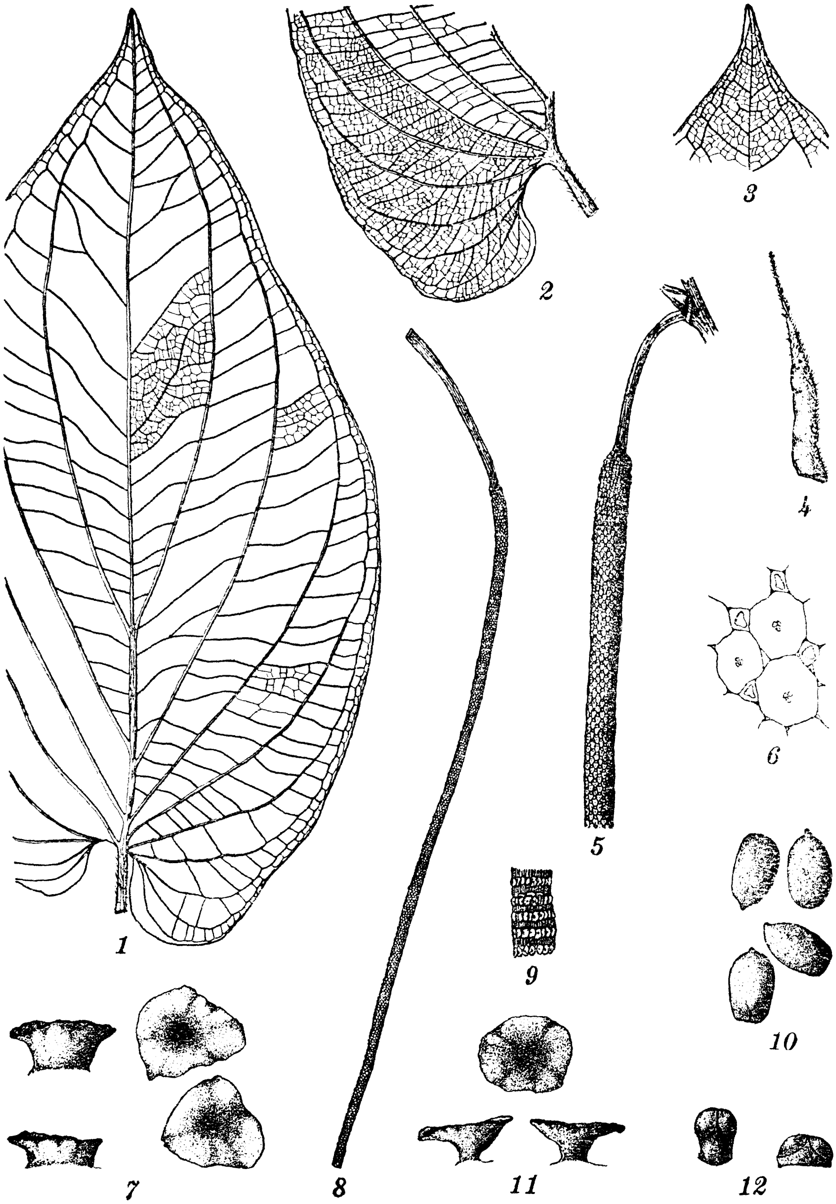


FIG. 16. *Piper majusculum* Blume; *1*, leaf with one side cut, × 0.5; *2*, lobe of the base of a leaf, × 0.5; *3*, tip of a leaf, × 0.5; *4*, stipule, × 0.5; *5*, portion of the pistillate spike, × 0.5; *6*, top view of portion of the pistillate spike, slightly enlarged; *7*, side and top views of pistillate bracts, × 7.5; *8*, staminate spike, × 0.5; *9*, portion of the staminate spike, × 1.5; *10*, seeds, × 5; *11*, top and side views of staminate bracts, × 7.5; *12*, stamens, × 7.5.

peltate, 0.2 to 0.4 mm long, disk glabrous, somewhat fleshy, suborbicular, 0.8 to 1 mm wide, pedicel short, somewhat fleshy; fruits immersed and concrescent, obovoid-obpyramid, 4- or 5-angled; seeds oblong, apex umbonate, 2 to 2.2 mm long, 0.8 to 1.2 mm in diameter; styles sessile; stigmas usually 3, rarely 4, subfleshy, rounded. Staminate spikes greatly elongated, slender, 21.5 to 43 cm long, 2 to 3 mm in diameter; the peduncles glabrous to pubescent, 2.5 to 4 cm long; rachis hirsute; bracts subsessile, peltate, disk glabrous, orbicular, 0.5 to 0.9 mm wide; stamens 2, subsessile, anthers 0.3 to 0.4 mm long, bilocular, 2-valved.

LUZON, Albay Province, without definite locality, *Vidal 3535:* Sorsogon Province, Mount Lalao, *Bur. Sci. 23405 Ramos;* Irosin, Mount Bulusan, *Elmer 14500, 15443.* SAMAR, without definite locality, *Bur. Sci. 17434 Ramos* (type collection of *Piper rotundistigmum* C. DC. var. *pilosius* C. DC.); Lauaan, *Bur. Sci. 43688 McGregor.* LEYTE, Dagami, *Bur. Sci. 15247, 15379 Ramos, Wenzel 214* (type collection of *Piper leyteanum* C. DC.) *463;* Jaro, *Wenzel 505, 657.* MINDANAO, Surigao Province, Placer, *Wenzel 1819, 2668;* Surigao, *Bur. Sci. 34537, 34547 Ramos and Pascasio:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13521, 14001:* Davao Province, without definite locality, *Copeland s. n.:* Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n.* (type of *Piper rotundistigmum* C. DC. in herb. Manila). In forests at low and medium altitudes. Sumatra, Borneo, Java, Amboina.

Local names: Ihaláson (Mbo.); tandáwon (Mbo.).

After critical study of all the Philippine material cited under *Piper majusculum* Blume, and a considerable number of extra-Philippine specimens, I consider that *Piper rotundistigmum* C. DC. and *Piper leyteanum* C. DC. are not distinct from *Piper majusculum* Blume. Miquel (1843) referred Blume's species to *Piper decumanum* Linn. and to *Piper methysticum* Linn.; both of these species are very distinct from *Piper majusculum* Blume.

15. **PIPER EUPODUM C. DC.** Text fig. 17.

Piper eupodum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 219, Candollea 1 (1923) 247; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

A diœcious vine; the young branches hirsute, older ones glabrous, terete, pale brown to brown, 1.5 to 3 mm in diameter, nodes hirsute. Leaves chartaceous, ovate, 7.5 to 10.2 cm long,

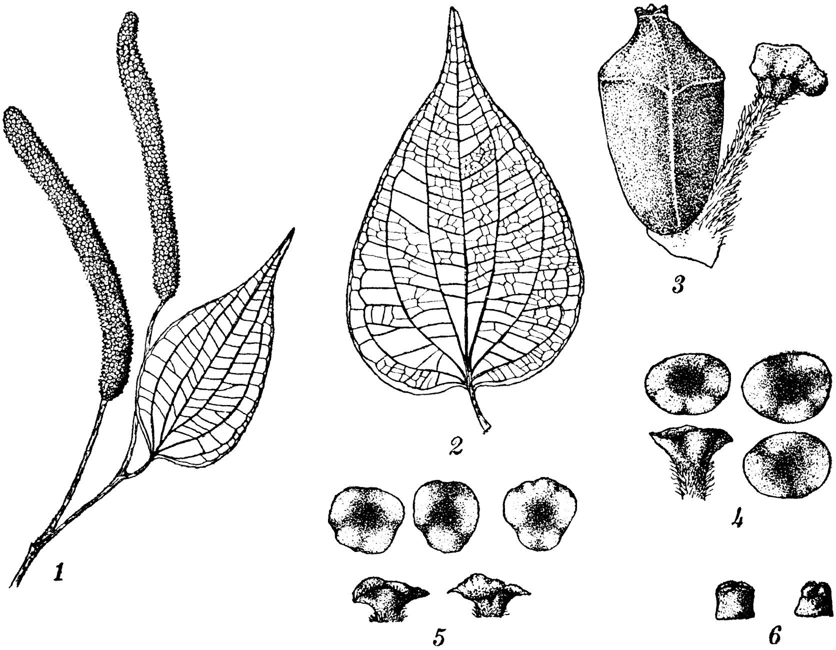


FIG. 17. *Piper eupodum* C. DC.; *1*, fruiting branch, × 0.5; *2*, leaf, × 0.5; *3*, fruit with a bract attached, × 10; *4*, top and apical side views of pistillate bracts, × 10; *5*, top and side views of staminate bracts, × 10; *6*, stamens, × 10.

3.2 to 6 cm wide, base equilaterally rounded, 7-plinerved, apex acutely acuminate, glabrous above, hirtellous on the nerves beneath, reticulations more or less prominent on both surfaces; petioles densely hirsute, 8 to 13 mm long. Pistillate spikes erect, elongated, slender, 7 to 8.5 cm long, 6.5 to 7 mm in diameter; the peduncles hirsute, 3.5 to 4.6 cm long; rachis densely hirsute; bracts long-pedicellate, peltate, 2 to 2.5 mm long, disk suborbicular, glabrous, 0.75 to 1 mm wide, pedicel densely hirsute, long, 1.75 to 2 mm long; fruits free, sessile, crowded, oblong-obovoid, 2.75 to 3 mm long, 1 to 1.5 mm in diameter, angled, glabrous; stigmas 3, sessile, apical, hirtellous. Staminate spikes suberect, 7 to 8.5 cm long, 2.25 to 2.5 mm in diameter; the peduncles hirsute, 4.5 to 5 cm long; rachis densely hirsute; bracts subsessile, peltate, 0.4 to 0.5 mm long, disk rounded-obovate, about 0.75 mm wide, glabrous, imbricate, pedicel somewhat stout and pilose at the base; stamens 2, somewhat pedicellate, 0.4 to 0.5 mm long, anthers tetralocular, 2-valved, cells ellipsoid, filaments oblong, stout, longer than the anthers.

LEYTE, Dagami, *Bur. Sci. 15227 Ramos;* Jaro Buenavista, *Wenzel 1005* (type collection). In forests, altitude about 500 meters. Endemic.

A species allied to *Piper arborescens* Roxb., differing in the size and form of its leaves, the erect pistillate spikes, and in having 2 stamens only.

16. PIPER MELANOCAULON sp. nov. Text fig. 18; Plate 5.

Frutex dioicus, scandens; ramulis glabris, nigrescentibus; foliis chartaceis, ovatis, 7.5 ad 10.8 cm longis, 3.6 ad 5.8 cm latis, basi subaequilateralibus obtusis ad rotundatis, 9-plinerviis, apice

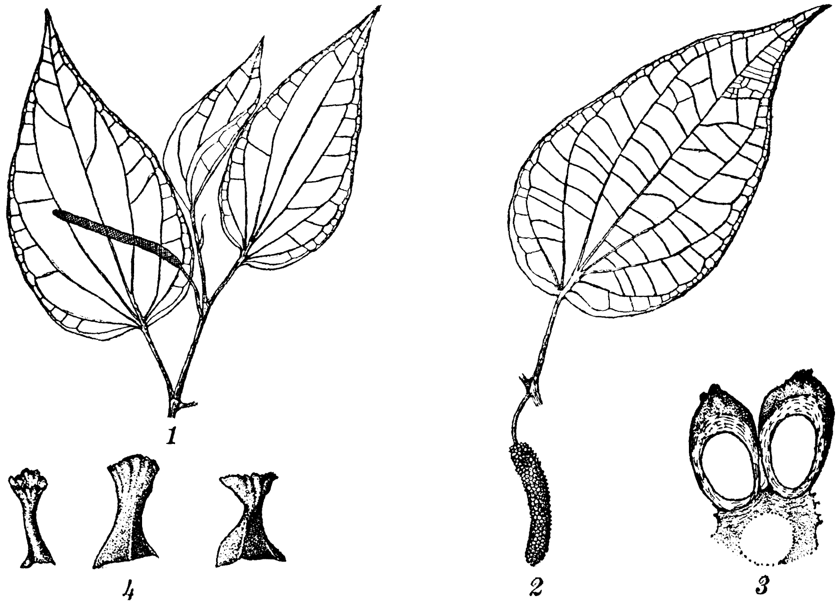


FIG. 18. *Piper melanocaulon* sp. nov.; *1*, a fruiting branch, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, portion of the transverse section of a mature pistillate spike, × 7.5; *4*, side view of pistillate bracts, × 7.5.

acute acuminatis, utrinque glabris; spicis ♀ subpendulis, gracilis, 2 ad 3.6 cm longis, 5 ad 5.5 mm diametro; bracteis pedicellatis, peltatis, 1 ad 1.25 mm longis, peltis orbicularis, adpressis, crenulatis, supra marginibusque glabris; baccis liberis, sessilibus, laxis, oblongo-subobovoideis, circiter 2 mm longis, 1 mm diametro; stigmatibus 3, rotundatis, sessilibus.

A diœcious vine; the branches glabrous, terete, black, 1.5 to 3 mm in diameter. Leaves chartaceous, somewhat black, ovate, 7.5 to 10.8 cm long, 3.6 to 5.8 cm wide, base subequilaterally

obtuse to rounded, 9-plinerved, apex acutely acuminate, entirely glabrous and smooth on both surfaces, reticulations subobscure to obscure above, somewhat prominent beneath; petioles glabrous, 15 to 22 mm long. Pistillate spikes slender, subpendulous, 2 to 3.6 cm long, 5 to 5.5 mm in diameter; the peduncles glabrous, 14 to 16 mm long; rachis glabrous; bracts pedicellate, peltate, 1 to 1.25 mm long, disk orbicular, 0.4 to 0.5 mm wide, glabrous, membranaceous, appressed, crenulate, pedicel stout, swollen at the base; fruits free, sessile, oblong-subobovoid, about 2 mm long, 1 mm in diameter, glabrous; stigmas 3, rounded, sessile, apical.

PANAY, Capiz Province, Mount Bolilao, *Bur. Sci. 35725* (type in herb. Manila), *35746 Martelino and Edaño,* June 29, 1919, on the summit, altitude about 1,000 meters.

The species resembles *Piper eupodum* C. DC., but may be readily distinguished from it by its black branches and leaves, shorter peduncles and spikes, laxly arranged fruits, its glabrous rachis, and its bracts.

17. PIPER AGUSANENSE C. DC. Text fig. 19.

Piper agusanense C. DC. in Leafl. Philip. Bot. 6 (1914) 2291, Philip. Journ. Sci. 11 (1916) Bot. 221, Candollea 1 (1923) 211; MERR., Enum. Philip. Fl. Pl. 2 (1923) 2.

A diœcious vine; the branches pilose, 2 to 3 mm in diameter. Leaves chartaceous, oblong to ovate-lanceolate, 7.5 to 13 cm long, 2 to 4.5 cm wide, the lower leaves ovate, 6 to 9 cm wide, base inequilaterally subcordate-auriculate, 7- to 9-plinerved, apex acute to acutely acuminate, glabrous above, pilose on the nerves and puberulent on the parenchyma beneath, upper surface somewhat scabrous, rigid when dry, reticulations subobscure to obscure above, somewhat prominent beneath; petioles slightly pilose, 0.5 to 2 cm long, of the lower leaves 2 to 3 cm long. Pistillate spikes erect, elongated, slender, 7.5 to 9 cm long, 5 to 5.5 mm in diameter; the peduncles glabrous, 3 to 3.5 cm long; rachis glabrous; bracts subsessile to sessile, peltate, 0.3 to 0.5 mm long, disk suborbicular, 0.8 to 1 mm wide, glabrous, fleshy; fruits crowded, partly embedded in and concrescent with the rachis, oblong to oblong-subobovoid, 2 to 2.2 mm long, about 1 mm in diameter; styles sessile; stigmas bilobed, tubercular, black. Staminate spikes subpendulous, slender, 6.5 to 11.5 cm long, 2 to 4 mm in diameter; the peduncles glabrous, 2 to 3.5 cm long; rachis glabrous; bracts subsessile, peltate, 0.3 to 0.5 mm long, disk rounded-ovate, glabrous, fleshy, 1 to 1.3 mm wide;

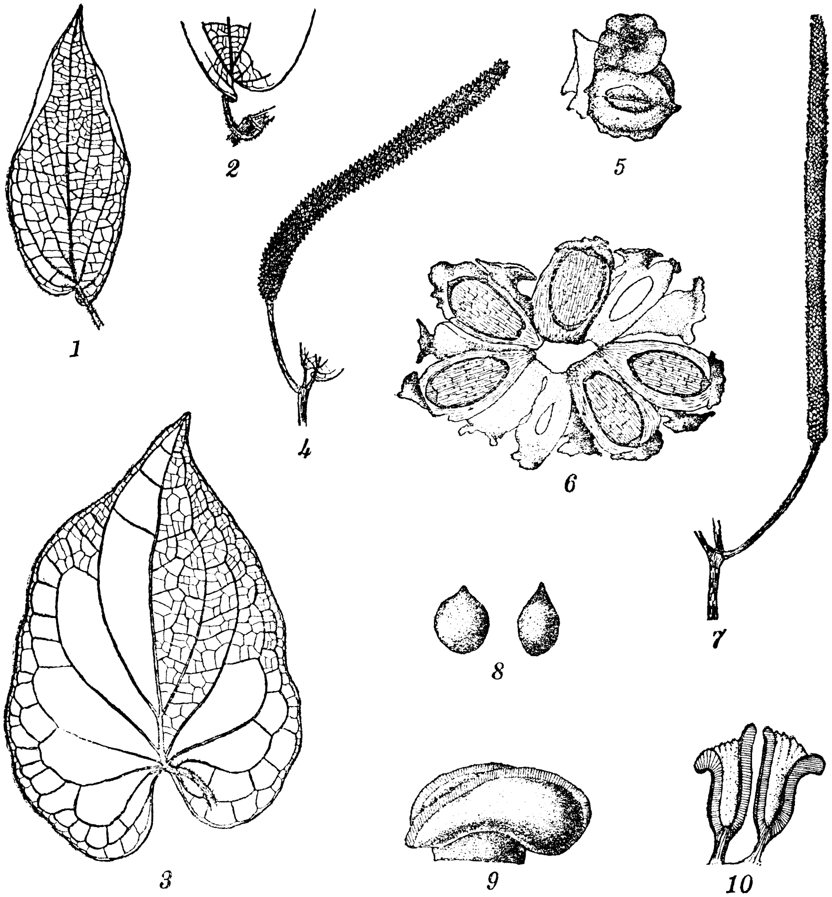


FIG. 19. *Piper agusanense* C. DC.; *1*, leaf, × 0.5; *2*, leaf base, × 0.5; *3*, lower leaf, × 0.5; *4*, mature pistillate spike, × 0.5; *5*, top view of a fruit and a bract, × 7.5; *6*, transverse section of a mature pistillate spike, × 7.5; *7*, mature staminate spike, × 0.5; *8*, top view of staminate bracts, × 7.5; *9*, side view of a stamen, × 40; *10*, median section of two stamens, × 40.

stamens 2, subsessile, 0.3 to 0.5 mm long, anthers ellipsoid, 2-valved, filaments shorter than the anthers.

LUZON, Laguna Province, Los Baños, Mount Maquiling, *Elmer 17499*. MINDANAO, Surigao Province, Placer, *Wenzel 3058:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13319* (type collection). CAMIGUIN DE MINDANAO, *Bur. Sci. 14644 Ramos*. In forests. Endemic.

Local name: Halopái (C. Bis., Mbo.).

A species characterized by its peculiar ellipsoid 2-valved anthers, its slender pistillate spikes, its fruits partly embedded in

and concrescent with the glabrous rachis, and its auriculate, somewhat scabrous leaves.

18. PIPER MERRILLII C. DC. Text fig. 20.

Piper merrillii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 426, 11 (1916) Bot. 212, Candollea 1 (1923) 213; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

Piper dagamiense C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 211, Candollea 1 (1923) 179; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches hirsute, 2 to 5 mm in diameter. Leaves membranaceous, with minute glandular black dots beneath, oblong-elliptic to subobovate-elliptic, 10 to 25 cm long, 4 to 13 cm wide, base somewhat narrowed, inequilateral, auriculate, 10- to 13-plinerved, apex acutely acuminate to acutely attenuate, glabrous above, hirtellous on the nerves beneath, reticulations prominent beneath; petioles hirsute, 1.5 to 3 cm long; stipules membranaceous, hirtellous on the outside, glabrous within. Pistillate spikes oblong, 1.8 to 3.2 cm long, 8 to 11 mm in diameter; the peduncles hirtellous, 5 to 10 mm long; rachis hirsute; bracts long-pedicellate, peltate, 1.5 to 2.5 mm long, disk suborbicular, 1 to 1.5 mm wide, glabrous, usually denticulate, pedicel hirsute; fruits free, partly embedded in and concrescent with the rachis, glabrous, oblong to oblong-ovoid, 3 to 3.2 mm in diameter; styles 1 to 1.5 mm; stigmas 2 or 3, papillate; seeds oblong to oblong-ovoid, glabrous, 2 to 2.8 mm long. Staminate spikes slender, 4.5 to 8 cm long, 4 to 5 mm in diameter; the peduncles hirtellous, 0.5 to 1.5 cm long; rachis hirsute; bracts pedicellate, peltate, 1 to 1.2 mm long, disk orbicular, glabrous, 1.5 to 2 mm wide, pedicel hirsute; stamens 2, subsessile to sessile, anthers oblong, apex truncate, more or less compressed, tetralocular, 4-valved.

LUZON, Isabela Province, San Mariano, *Bur. Sci. 47220 Ramos and Edaño:* Laguna Province, San Antonio, *Bur. Sci. 20557 Ramos:* Tayabas Province, Mount Binuang, *Bur. Sci. 28591 Ramos and Edaño.* ALABAT, *Bur. Sci. 48273, 48356 Ramos and Edaño.* MINDORO, Baco River, *Merrill 1809* (type of *Piper merrillii* C. DC. in herb. Manila), *4038, McGregor 178;* Mount Calavite, *Bur. Sci. 39431 Ramos;* Mount Halcon, *Bur. Sci. 40575, 40709 Ramos and Edaño.* SAMAR, Cauayan, *Bur. Sci. 17527, Ramos;* Catubig River, *Bur Sci. 24331, 24550 Ramos.* LEYTE, Dagami, *Bur. Sci. 15181 Ramos* (type collection of *Piper dagamiense* C. DC.). NEGROS, Occidental Negros Province, Canlaon Volcano, *Banks s. n., Merrill 7033;* Mount Silay, *Whitford 1547.* PANAY, Capiz Province, Mount Macosolon, *Bur. Sci.*

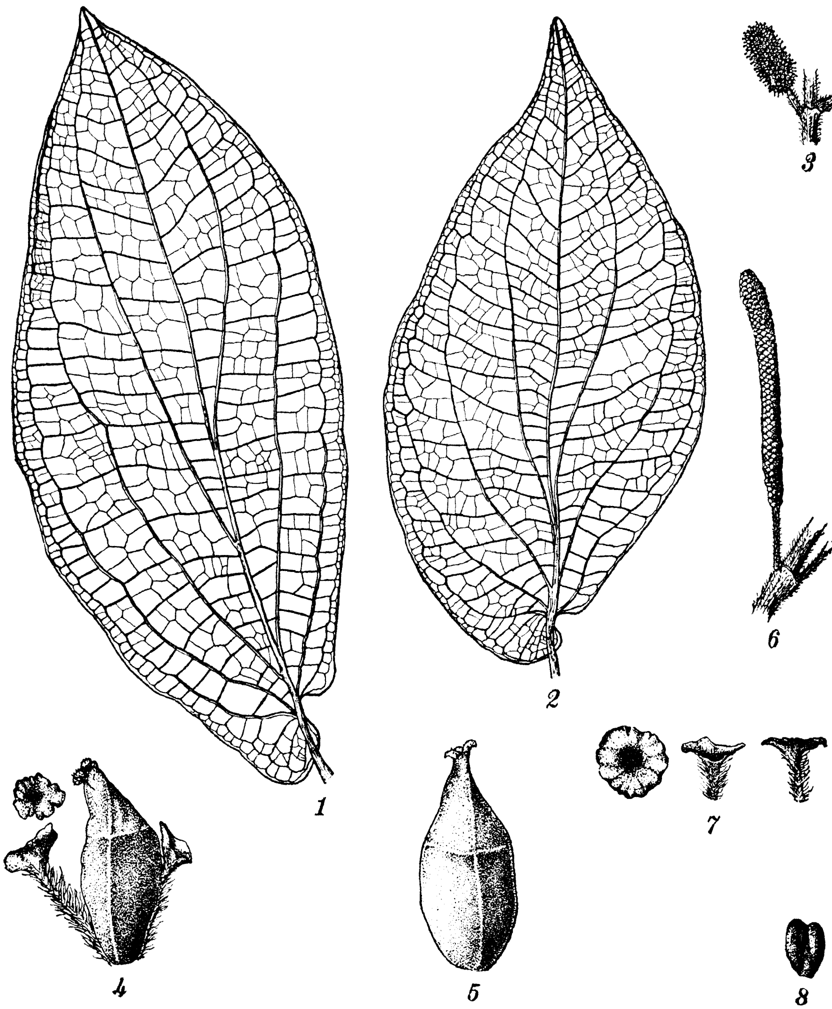


FIG. 20. *Piper merrillii* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, submature fruit and bracts, × 7.5; *5*, mature fruit, × 7.5; *6*, staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamen, × 7.5.

30777 Ramos and Edaño; Jamindan, *Bur. Sci. 31349, 31377 Ramos and Edaño;* Libacao, *Bur. Sci. 31425 Ramos and Edaño:* Antique Province, Culasi, *Bur. Sci. 32493 McGregor.* BOHOL, Valencia, *Bur. Sci. 42845 Ramos.* PALAWAN, Mount Capoas, *Merrill 9505.* MINDANAO, Davao Province, Mount Galintan, *Bur. Sci. 48876 Ramos and Edaño.* In forests at low, medium, and high altitudes, ascending to 1,250 meters. Endemic.

Local names: Buyat-halo (P. Bis.); parong (Bis.).

This species is allied to *Piper stylosum* Miq., from which it is distinguished by its auriculate leaves and much smaller fruits.

19. PIPER ARISTOLOCHIPHYLLUM sp. nov. Text fig. 21; Plate 6.

Frutex dioicus, scandens; ramulis puberulis, nigrescentibus, 2 ad 3 mm diametro; foliis oblongis, 14.5 ad 21 cm longis, 5 ad 7.5 cm latis, basi inaequilateralibus, subauriculatis, penninerviis, apice obscure acute acuminatis, supra glabris, nigrescentibus, subtus ad nervis minutissime puberulis, membranaceis; petiolo 1 ad 1.5 cm longo; spicis ♂ gracilis, cylindricis, 6 ad 9 cm longis, 3 ad 5 mm diametro; pedunculis 1 ad 1.5 cm longis, puberulis; bracteis pedicellatis, peltatis, 1 mm longis, peltis supra marginibusque glabris, orbicularis, 1 ad 1.2 mm latis, pedicellis puberulis; staminibus 2, antheris subglobosis, 4-valvatis.

A diœcious vine; the branches 2 to 3 mm in diameter, puberulent, black, terete. Leaves membranaceous, brown black when dry above, pale, silvery and with minute black glandular dots beneath, oblong, 14.5 to 21 cm long, 5 to 7.5 cm wide, base inequilaterally subauriculate, penninerved, apex obscurely and

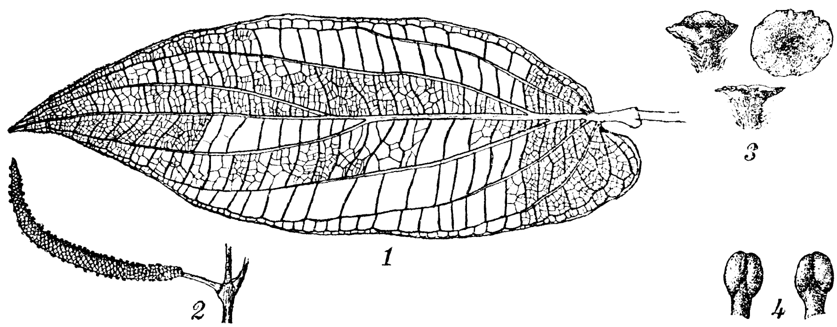


FIG. 21. *Piper aristolochiphyllum* sp. nov.: *1*, leaf, × 0.5; *2*, staminate spike, × 0.5; *3*, side and top views of staminate bracts, × 7.5; *4*, stamens, × 7.5.

acutely acuminate, glabrous above, puberulent on the nerves beneath, nerves prominently black beneath, reticulations black, rather prominent beneath; petioles 1 to 1.5 cm long, puberulent, black. Staminate spikes slender, 6 to 8 cm long, 3 to 5 mm in diameter; the peduncles 1 to 1.5 cm long, puberulent, black; rachis puberulent; bracts pedicellate, peltate, about 1 mm long, disk orbicular, glabrous, 1 to 1.2 mm wide, pedicel fleshy, puberulent; stamens 2, pedicellate, about 1 mm long, anthers subglobose, 4-valved.

LUZON, Tayabas Province, Mount Alzapan, *Bur. Sci. 45695 Ramos and Edaño* (type in herb. Manila), June 6, 1925, on forested slopes, altitude about 1,500 meters.

This species is allied to *Piper merrillii* C. DC., but differs essentially in the black, puberulent leaves, branches, peduncles, and petioles, its pedicellate stamens, and its subglobose anthers.

20. PIPER AURILIMBUM C. DC. Text fig. 22.

Piper aurilimbum C. DC. in Leafl. Philip. Bot. 3 (1910) 768, Philip. Journ. Sci. 5 (1910) Bot. 425, 11 (1916) Bot. 210, Candollea 1 (1923) 202; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

A diœcious vine; the young branches hirsute, older ones glabrous, terete, 2 to 4 mm in diameter. Leaves membranaceous, with numerous black glandular dots beneath, oblong-elliptic to obovate-elliptic, 10 to 18 cm long, 3.5 to 8 cm wide, base inequilaterally subcordate, prominently auriculate, 7-plinerved, very rarely penninerved, apex shortly and acutely acuminate, glabrous above, hirtellous on the nerves beneath, reticulations

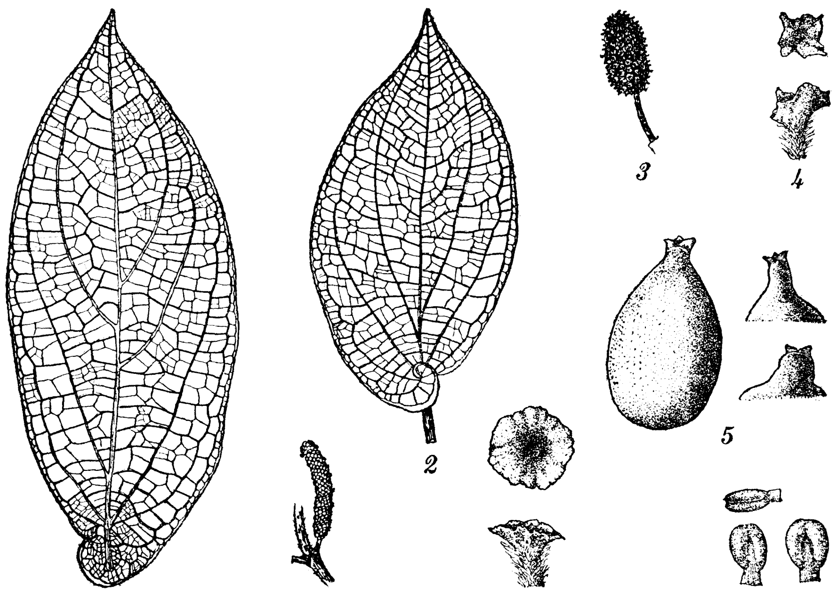


FIG. 22. *Piper aurilimbum* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, top and side views of pistillate bracts, × 7.5; *5*, fruit and apices of fruits, × 7.5; *6*, staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamens, × 7.5.

somewhat obscure above, prominent beneath; petioles hirsute, 0.5 to 1 cm long, in the lower leaves up to 3.5 cm long. Pistillate spikes oblong, 2 to 4.3 cm long, 5 to 10 mm in diameter; the peduncles hirsute, 1.2 to 3 cm long; rachis pilose; bracts pedicellate, peltate, 0.8 to 1.2 mm long, disk glabrous, suborbicular, about 0.75 mm wide, pedicel fleshy, pilose; fruits oblong, acuminate, about 3 mm long, 1.2 to 1.5 mm in diameter, more or less concrescent at the base; stigmas 3, ovoid, acute; seeds glandular, oblong-obovoid, about 2 mm long. Staminate spikes about 2.5 cm long, 3 to 5 mm in diameter; the peduncles hir-

sute, 3.5 to 5 mm long; rachis pilose; bracts pedicellate, peltate, about 1 mm long, disk orbicular, 1 to 1.2 mm wide, glabrous, pedicel fleshy, pilose; stamens 2, subpedicellate, about 1 mm long, anthers oblong, rounded, tetralocular, 4-valved, filaments shorter than the anthers.

LUZON, Cagayan Province, Abulug River, *Weber 1584;* Dabba, *Bur. Sci. 13946 Ramos;* without definite locality, *Bur. Sci. 13980 Ramos;* La Union Province, Disdis, *Lete 711:* Kalinga Subprovince, Mount Masingit, *Bur. Sci. 37566, 37568, 37591 Ramos and Edaño:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19821 McGregor:* Benguet Subprovince, Baguio, *Elmer 8866* (type collection): Rizal Province, without definite locality, *Loher 14910.* In forests at medium altitudes. Endemic.

Local names: Dawn-sha-atab (Ig.); ganed (Ig.); ganid (Ig.).

This species bears considerable resemblance to *Piper merrillii* C. DC., but has more prominently auriculate leaves, subpedicellate stamens, and shorter pistillate bracts.

21. PIPER MYRMECOPHILUM C. DC. Text fig. 23.

Piper myrmecophilum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 211, Candollea 1 (1923) 178; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

A diœcious vine; the branches villose, terete, 2 to 4 mm in diameter. Leaves chartaceous, oblong to oblong-ovate, 17.5 to 25.5 cm long, 6 to 8.5 cm wide, base inequilaterally cordate-auriculate, 11- to 13-plinerved, with a rounded reflexed ant sac attached to the petiole, apex acutely acuminate, glabrous and shining on both surfaces, reticulations more or less prominent above, prominent beneath; petioles hirsute, 6 to 8 mm long. Pistillate spikes oblong to oblong-obovoid, 4 to 5.5 cm long, 1.8 to 2.5 cm in diameter; the peduncles hirsute, 7 to 10 mm long; rachis hirsute; bracts long-pedicellate, peltate, 3.5 to 4 mm long excluding the projections, disk small, glabrous, suborbicular, 0.5 to 1 mm wide, with 2 to 6 projections, the projections 1.1 to 1.8 mm long, multicellular, pedicel long, villose; fruits free, 8.5 to 10.5 mm long with the styles; styles very long, 6.5 to 8.5 mm long, glabrous; stigmas 2, shortly bifid, hispidulous; seeds ellipsoid, 2 to 2.2 mm long. Staminate spikes narrowly oblong, about 3 cm long, 0.5 to 0.6 mm in diameter; the peduncles hirsute, 6 to 7 mm long; rachis hirsute; bracts pedicellate, peltate, 1.5 to 2 mm long, disk glabrous, suborbicular, 0.75 to 1 mm wide, with 3 projections attached at the edge of the disk; stamens 2, pedicellate, 1.2 to 1.8 mm long, anthers

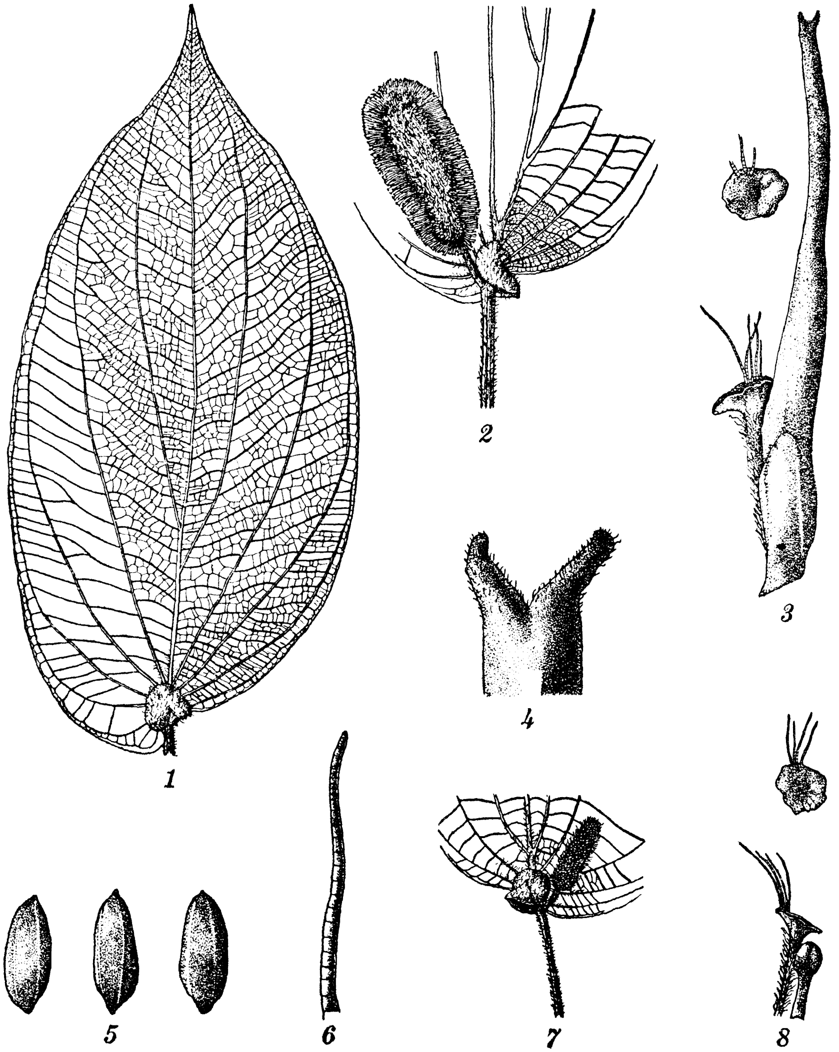


FIG. 23. *Piper myrmecophilum* C. DC.; *1*, leaf, × 0.5; *2*, base of a leaf and mature pistillate spike, × 0.5; *3*, fruit with long style and bracts, × 7.5; *4*, detail of bifid stigmas, × 10; *5*, seeds, × 7.5; *6*, detail of a projection from the pistillate bract, × 10; *7*, base of a leaf and mature staminate spike, × 0.5; *8*, top and side views of bracts and stamen, × 7.5.

oblong, tetralocular, 4-valved, filaments somewhat slender, longer than the anthers.

SAMAR, Mount Cauayan, *Bur. Sci. 17599 Ramos* (type collection); Camanabaan, *Bur. Sci. 24366 Ramos;* Pinipisakan, Catubig River, *Bur. Sci. 24345, 24346 Ramos.* LEYTE, Tigbao,

Wenzel 1464; Tacloban, *Wenzel 1778.* In damp forests at low and medium altitudes. Endemic.

This is the only Philippine species of *Piper* with myrmecophylous leaves. It is strongly characterized by the long, multicellular projections of the bracts, the long styles, the bifid, hispidulous stigmas, and the peculiar ant sac at the base of the lamina.

22. **PIPER ABBREVIATUM** Opiz. Text figs. 24 and 25; Plate 17, fig. 9.

Piper abbreviatum OPIZ in Presl Rel. Haenk. 1 (1828) 157; C. DC. in Leafl. Philip. Bot. 3 (1910) 775; MERR., Enum. Philip. Fl. Pl. 2 (1923) 2.

Piper chaba BLUME in Verh. Bat. Genoots. 11 (1826) 168, *f. 7;* C. DC., Prodr. 16^1 (1869) 347, Philip. Journ. Sci. 5 (1910) Bot. 432 (incl. formæ *b*, *c*, *d*, and *e* C. DC.), 11 (1916) Bot. 216, Candollea 1 (1923) 195, 214; F.-VILL., Novis App. (1880) 175, non Hunter As. Res. 9 (1809) 391.

Chavica chaba MIQ., Syst. Pip. (1843) 251, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 37, *t. 31*, Fl. Ind. Bat. 1^2 (1858–59) 443.

Piper rhombophyllum C. DC. Prodr. 16^1 (1869) 352, Leafl. Philip. Bot. 3 (1910) 775, Philip. Journ. Sci. 5 (1910) Bot. 433, 11 (1916) Bot. 216, Candollea 1 (1923) 214; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 220; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

Chavica populifolia MIQ., Syst. Pip. (1843) 248, Fl. Ind. Bat. 1^2 (1858–59) 442 non *Piper populifolium* Opiz.

Piper rhombifolium F.-VILL., Novis, App. (1880) 175, sphalm.

Piper miquelinum F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper rubripunctulatum C. DC. in Perk. Frag. Fl. Philip. (1905) 158, Candollea 1 (1923) 274.

Piper parvispica C. DC. in Perk. Frag. Fl. Philip. (1905) 156, Candollea 1 (1923) 267.

Piper mearnsii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 447, Candollea 1 (1923) 174; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

A diœcious vine; the branches glabrous, terete, 1.5 to 3 mm in diameter. Leaves membranaceous to chartaceous, ovate, ovate-lanceolate, elliptic-oblong or rounded-elliptic, 4 to 14 cm long, 1.5 to 6.7 cm wide, base usually equilaterally cuneate, sometimes subequilaterally acute to obtuse, rarely rounded, usually 5-plinerved, rarely 3-plinerved or 7-plinerved, apex acuminate to attenuate, the acumen acute to subobtuse, glabrous on both surfaces, somewhat glaucous on the lower surface, reticulations somewhat obscure above, more or less prominent beneath; petioles glabrous, 4 to 15 mm long, in the lower leaves up to 25 mm long. Pistillate spikes abbreviated, oblong to globose-ovoid, obtuse to rounded, 7 to 20 mm long, 7.5 to 11 mm in diameter; the peduncles glabrous, 0.8 to 2 cm long; rachis sparsely hir-

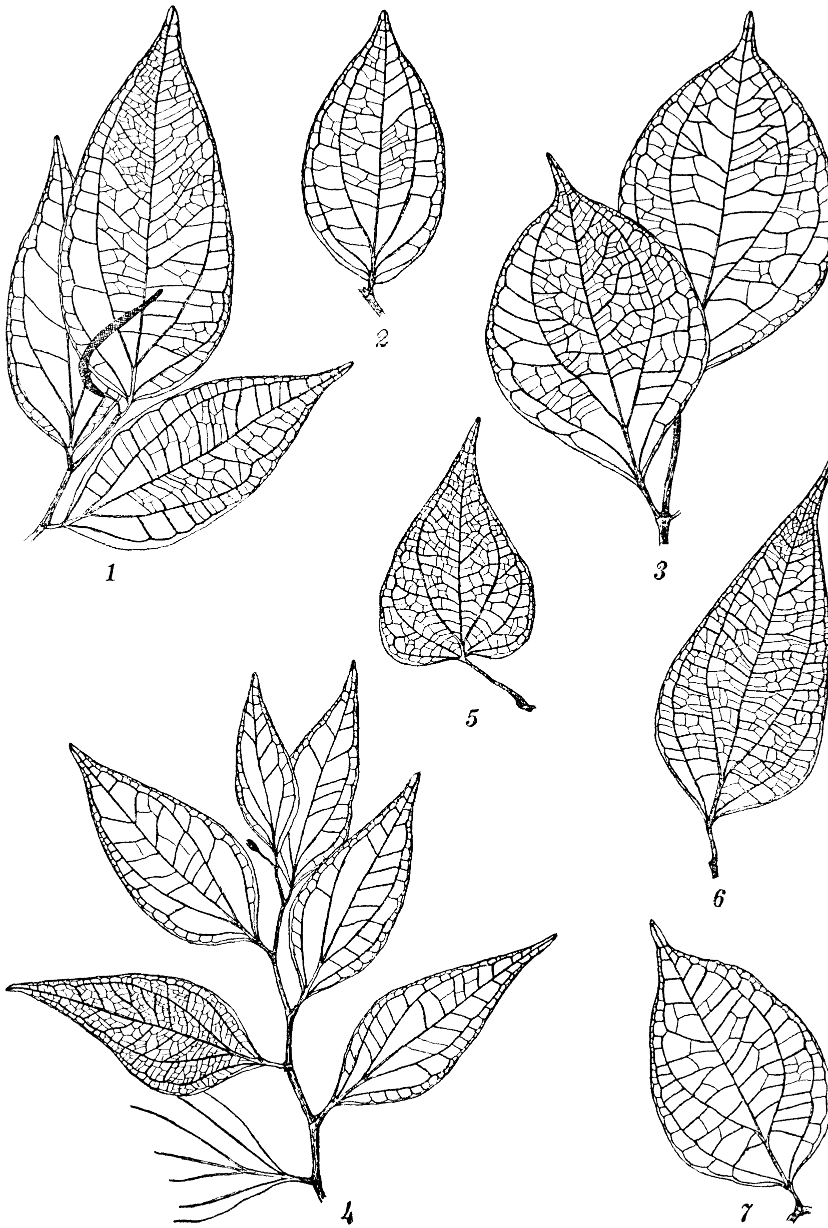

1
2
3
5
6
4
7

FIG. 24. *Piper abbreviatum* Opiz; *1*, flowering branch of a male plant, × 0.5; *2–3*, leaves, × 0.5; *4*, flowering branch of a female plant, × 0.5; *5*, lower leaf, × 0.5; *6–7*, leaves, × 0.5.

sute; bracts sessile, peltate, disk glabrous, transversely subelliptic to obovate, 0.5 to 0.8 mm wide; fruits crowded, coalescing, fully embedded in and concrescent with the rachis, oblanceolate

to obovoid, angled, glabrous, apex umbonate, the product of somewhat elongated styles, these about 3 mm long; stigmas 3 or 4, ovoid, sessile, apical; seeds obovoid, oblong-obovoid, or oblanceolate, 2 to 2.5 mm long. Staminate spikes slender, 2.2 to 5.7 cm long, 1.5 to 3 mm in diameter; the peduncles glabrous, 4 to 18 mm long; rachis hirsute; bracts subsessile, peltate, 0.5 to 0.6 mm long, disk transversely subelliptic, glabrous, 0.5 to 0.6 mm wide, pedicel stout, hirsute; stamens 2, pedicellate, 0.6 to 1 mm long, anthers reniform to subglobose, 2-valved, filaments slightly longer than the anthers, somewhat exerted.

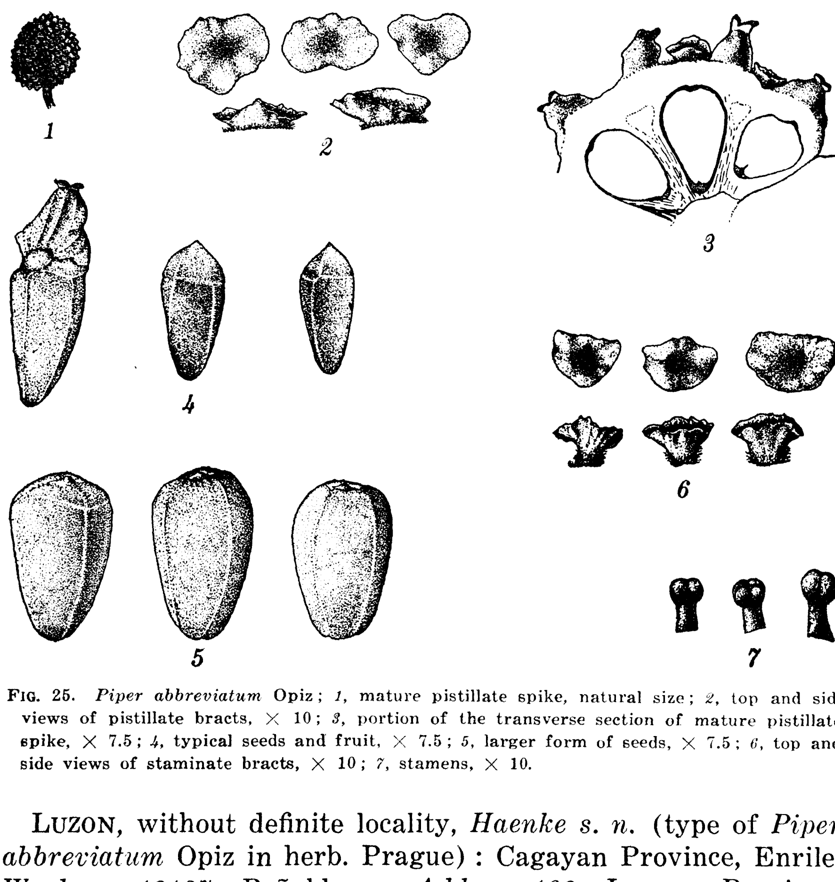


FIG. 25. *Piper abbreviatum* Opiz; *1*, mature pistillate spike, natural size; *2*, top and side views of pistillate bracts, × 10; *3*, portion of the transverse section of mature pistillate spike, × 7.5; *4*, typical seeds and fruit, × 7.5; *5*, larger form of seeds, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

LUZON, without definite locality, *Haenke s. n.* (type of *Piper abbreviatum* Opiz in herb. Prague): Cagayan Province, Enrile, *Warburg 12127;* Peñablanca, *Adduru 132:* Laguna Province, San Antonio, *Bur. Sci. 16608, 20520, 20582 Ramos;* Calauan, *Callery 64;* Mount Maquiling, Los Baños, *Elmer 17513, 18202, Juliano 1081, Bur. Sci. 17003 Robinson, Foxworthy 21, 32, Gates 5245, For. Bur. 26376 Catalan, 26902 Mabesa:* Tayabas Prov-

ince, Kabibihan, *Bur. Sci. 13282 Ramos;* Mount Binuang, *Bur. Sci. 28710, 28749 Ramos and Edaño;* Casiguran, *Bur. Sci. 2987 Mearns* (type of *Piper mearnsii* C. DC. in herb. Manila), *45569 Ramos and Edaño:* Camarines Norte Province, Paracale, *Bur. Sci. 33641 Ramos and Edaño:* Camarines Sur Province, Sagnay, *Bur. Sci. 22150 Ramos;* Mount Isarog, *Bur. Sci. 22077 Ramos:* Albay Province, without definite locality, *Cuming 834* (type of *Chavica populifolia* Miq. in herb. Kew; isotype in herb. Manila): Sorsogon Province, without definite locality, *Bur. Sci. 23464 Ramos;* Mount Bulusan, Irosin, *Elmer 14591, 16249.* POLILLO, *Bur. Sci. 10234 McGregor, 9128 Robinson.* CATANDUANES, Calolbong, *Bur. Sci. 30261 Ramos;* Bacon, *For. Bur. 29865, 29867 Denaga.* BATAN, *Bur. Sci. 6231, 6429 Robinson.* MINDORO, Mount Calavite, *Bur. Sci. 39421 Ramos;* Mount Halcon, *Bur. Sci. 4066 Ramos and Edaño.* SAMAR, Mount Canislagan, *Bur. Sci. 17507 Ramos;* Catubig River, *Bur. Sci. 24223, 24261, 24300 Ramos;* Loquilocon, *Bur. Sci. 43862 McGregor.* LEYTE, Mount Abucayan, *Bur. Sci. 41759 Edaño;* Dagami, *Wenzel 19, 40, 419, 434;* Tigbao, Tacloban, *Wenzel 1244, 1647.* SIBUYAN, Magallanes, *Elmer 12405.* PANAY, Capiz Province, Libacao, *Bur. Sci. 35303, 35312 Martelino and Edaño;* Mount Salibongbong, *Bur. Sci. 35566 Martelino and Edaño;* Mount Timbaban, *Bur. Sci. 42350 Edaño;* Mount Kinabdangan, *Bur. Sci. 45999 Edaño:* Antique Province, Culasi, *Bur. Sci. 32545 McGregor.* BOHOL, Dimiao, *Bur. Sci. 42626 Ramos;* Bilar, *Bur. Sci. 42704 Ramos.* SIARGAO, Dapa, *Bur. Sci. 34849, 34887 Ramos and Pascasio.* CAMIGUIN DE MINDANAO, Mount Catarman, *Philip. Pl. 1286 Ramos.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34528 Ramos and Pascasio;* Placer, *Wenzel 1843, 1878, 2855;* without definite locality, *Bolster 351:* Bukidnon Province, without definite locality, *Bur. Sci. 21441 Escritor;* Tangkulan, *Bur. Sci. 24954 Fénix;* Gimbaluron, *Rola 66:* Agusan Province, without definite locality, *Bur. Sci. 15881 Fénix;* Agusan River, *Weber 1205;* Cabadbaran, Mount Urdaneta, *Elmer 13318, 13429, 13522, 13768:* Davao Province, without definite locality, *Warburg 14746* (type of *Piper rubripunctulatum* C. DC. in herb. Berlin; isotype in herb. Manila); Santa Cruz, *Copeland 1315;* Davao, *Copeland 327;* Mount Apo, *Elmer 11077, Bur. Sci. 49417, 49468, 49512 Ramos and Edaño;* Mati, *Bur. Sci. 49178 Ramos and Edaño;* Mount Dagatpan, *Warburg 14750* (type of *Piper parvispicum* C. DC. in herb. Berlin; isotype in herb. Manila); Taumo, *Warburg 14747:* Lanao Prov-

ince, Lake Lanao, Camp Keithley, *Clemens s. n.:* Zamboanga Province, Sax River, *Merrill 8253, Williams 2130;* Mount Tubuan, *Bur. Sci. 36672 Ramos and Edaño;* Malangas, *Bur. Sci. 36845, 37104, 37298 Ramos and Edaño.* BASILAN, *Bur. Sci. 15454, 16346 Reillo.* TAWITAWI, *Bur. Sci. 44218 Ramos and Edaño.* In forests at low and medium altitudes, throughout the Philippines. Borneo, Java.

Local names: Alapàpan (Mbo.); bagaybajon (Mbo.); buyo-buyo (Bik.); buyo-halo (P. Bis.); buyong-amo (Sub.); gutí-gutí (Bik.); halopai (Mbo.); kaligu-uan (Lan.); laiñgan (Sub.); lauigang (Tag., Sub.); lingolingo-daytoi (Bis.); manikatápai (Bag.); patai-patai (Sub.); samaina (Mbo.); tandanon (Mbo.).

A species characterized by its abbreviated pistillate spikes and its crowded, coalesced, and umbonate fruits.

23. **PIPER BREVIAMENTUM** C. DC. Text figs. 26 and 27.

Piper breviamentum C. DC. in Philip. Journ. Sci. **5** (1910) Bot. 434, Candollea **1** (1923) 214; MERR., Enum. Philip. Fl. Pl. **2** (1923) 4.

Piper copelandii C. DC. in Philip. Journ. Sci. **5** (1910) Bot. 447, Candollea **1** (1923) 174; MERR., Enum. Philip. Fl. Pl. **2** (1923) 15.

Piper sarcostylum C. DC. in Philip. Journ. Sci. **11** (1916) Bot. 216, Candollea **1** (1923) 214; MERR., Enum. Philip. Fl. Pl. **2** (1923) 15.

A diœcious vine; the branches glabrous, terete, 1.5 to 5 mm in diameter. Leaves chartaceous, elliptic-lanceolate to elliptic-ovate, rarely ovate, the upper ones 10 to 14 cm long, 3 to 6.5 cm wide, rarely 5.5 to 6.5 cm long, 1.5 to 2.5 cm wide, lower leaves up to 17.5 cm long and 10 cm wide, base equilaterally acute, very rarely obtuse or rounded, 7- to 9-penninerved in the lower leaves up to 11-penninerved, apex acutely acuminate, glabrous on both surfaces, lower surface smooth, never glaucous, reticulations somewhat obscure above, prominent beneath; petioles glabrous, 6 to 15 mm long, in the lower leaves up to 35 mm long. Pistillate spikes usually abbreviated, oblong, obtuse to rounded, 1 to 2.5 cm long, 5 to 10 mm in diameter, very rarely 3.5 to 4.3 cm long; the peduncles glabrous, 7 to 15 mm long; rachis hirsute; bracts sessile, peltate, disk glabrous, orbicular, 0.5 to 0.6 mm wide; fruits coalescing, embedded in and concrescent with the rachis, apex exerted, umbonate, the product of somewhat elongated styles; stigmas 3, ovoid, hirtellous, sessile, apical; seeds usually subellipsoid, rarely oblong-subovoid, 2 to 3 mm long, 0.75 to 1.25 mm in diameter, angled. Hermaphroditic spikes like the female; stamens 2, pedicellate, 1 to 1.25

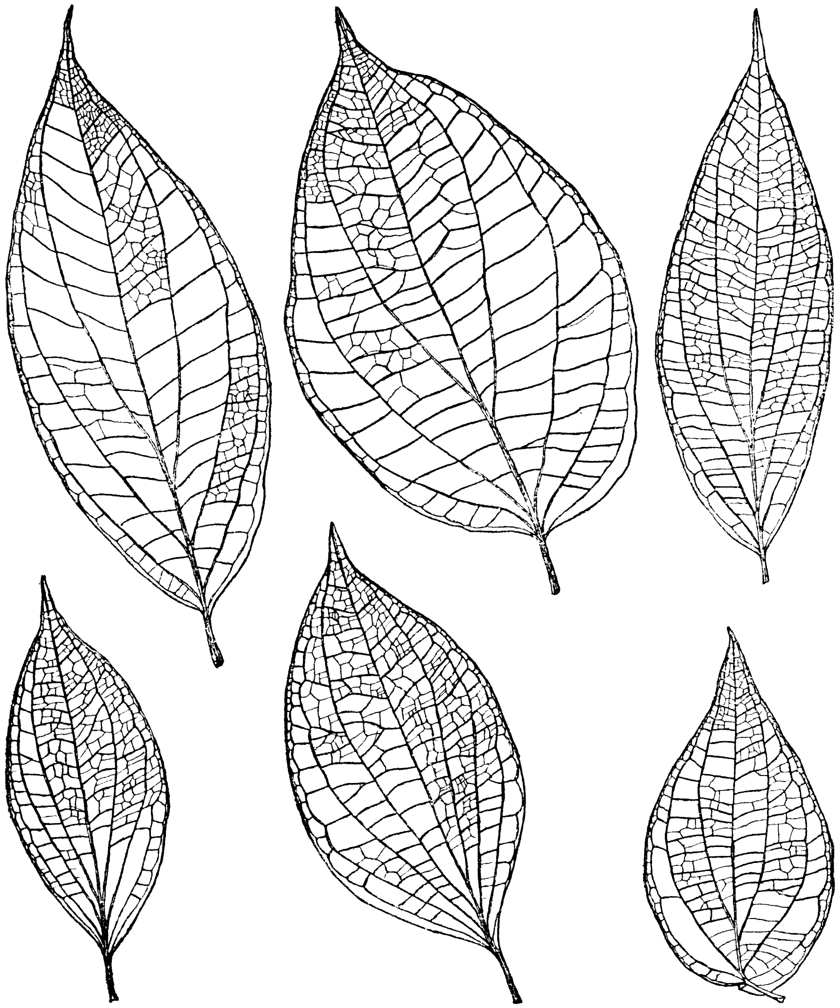


FIG. 26. *Piper breviamentum* C. DC.; leaves, × 0.5.

mm long, anthers oblong, small, tetralocular, 2-valved, filaments very slender, longer than the anthers, exerted.

LUZON, Laguna Province, Mount San Cristobal, *Juliano 1088:* Tayabas Province, Mount Binuang, *Bur. Sci. 28722 Ramos and Edaño.* LEYTE, Jaro, Buenavista, *Wenzel 802;* Tigbao, *Wenzel 1585.* PANAY, Capiz Province, Jamindan, *Bur. Sci. 30937, 31197, 31210, 31380 Ramos and Edaño;* Libacao, *Bur. Sci. 35305, 35515 Martelino and Edaño;* Mount Agsamilig, *Bur. Sci. 46033 Edaño;* Mount Kinablagan, *Bur. Sci. 46081 Edaño.* BOHOL,

Batuan River, *Bur. Sci. 42656 Ramos;* Bilar, *Bur. Sci. 42698 Ramos;* Kalingohan, *Bur. Sci. 42797 Ramos;* Valencia, *Bur. Sci. 42831 Ramos.* MINDANAO, Surigao Province, Placer, *Wenzel 1894, 1905, 2805, 2881, 3195;* Surigao, *Bur. Sci. 34409, 34467 Ramos and Pascasio:* Agusan Province, Agusan River, *Merrill 7305* (type collection of *Piper sarcostylum* C. DC.): Davao Province, Todaya, *Copeland 1298* (type of *Piper copelandii* C. DC. in herb. Manila): Zamboanga Province, Sax River, *Williams 2104* (type of *Piper breviamentum* C. DC. in herb. Manila). In forests at low and medium altitudes, ascending to 1,200 meters. Endemic.

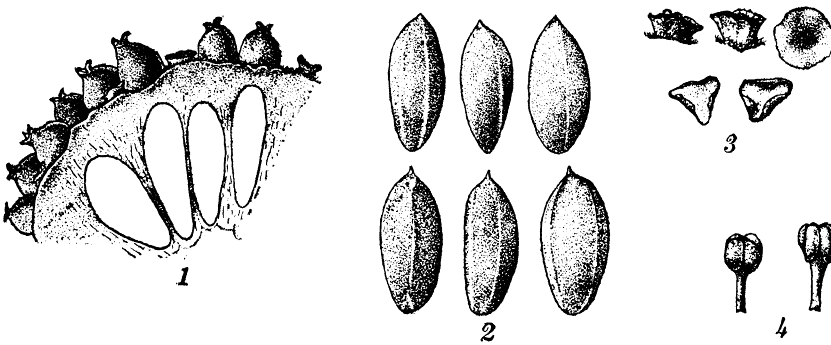


FIG. 27. *Piper breviamentum* C. DC.; *1*, portion of the transverse section of a mature pistillate spike, × 7.5; *2*, seeds, × 7.5; *3*, side and top views of staminate bracts, × 10; *4*, stamens, × 10.

Local name: Buyong-sinhalo (P. Bis.).

A species closely allied to *Piper abbreviatum* Opiz, differing in its penninerved, never glaucous leaves. It is also differentiated by having hermaphroditic spikes. *Piper copelandii* C. DC. was erroneously placed under section *Coccobryon* by C. de Candolle.[6] It actually belongs to the section *Eupiper.*

Var. PUBERULINERVUM var. nov.

Subtus foliis ad nervis puberulis; spicis hermaphroditis.

Nerves on the lower surface of the leaves puberulent; spikes hermaphroditic.

MINDANAO, Bukidnon Province, Mount Candoon, *Bur. Sci. 38832 Ramos and Edaño* (type in herb. Manila), June 25, 1920, in forests, altitude about 1,150 meters.

This is distinguished from the species by the nerves on the lower surface of the leaves being puberulent.

[6] Candollea 1 (1923) 174.

24. PIPER PARCIRAMEUM C. DC. Text fig. 28.

Piper parcirameum C. DC. in Leafl. Philip. Bot. 3 (1910) 781, Philip. Journ. Sci. 5 (1910) Bot. 445, Candollea 1 (1923) 211; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A lax undershrub, about 0.6 meter high; the branches glabrous, smooth, subterete, 2 to 4.5 mm in diameter. Leaves chartaceous, with conspicuous dark red dots beneath, oblong-elliptic to lanceolate, 14 to 23 cm long, 3.5 to 7 cm wide, base inequi-

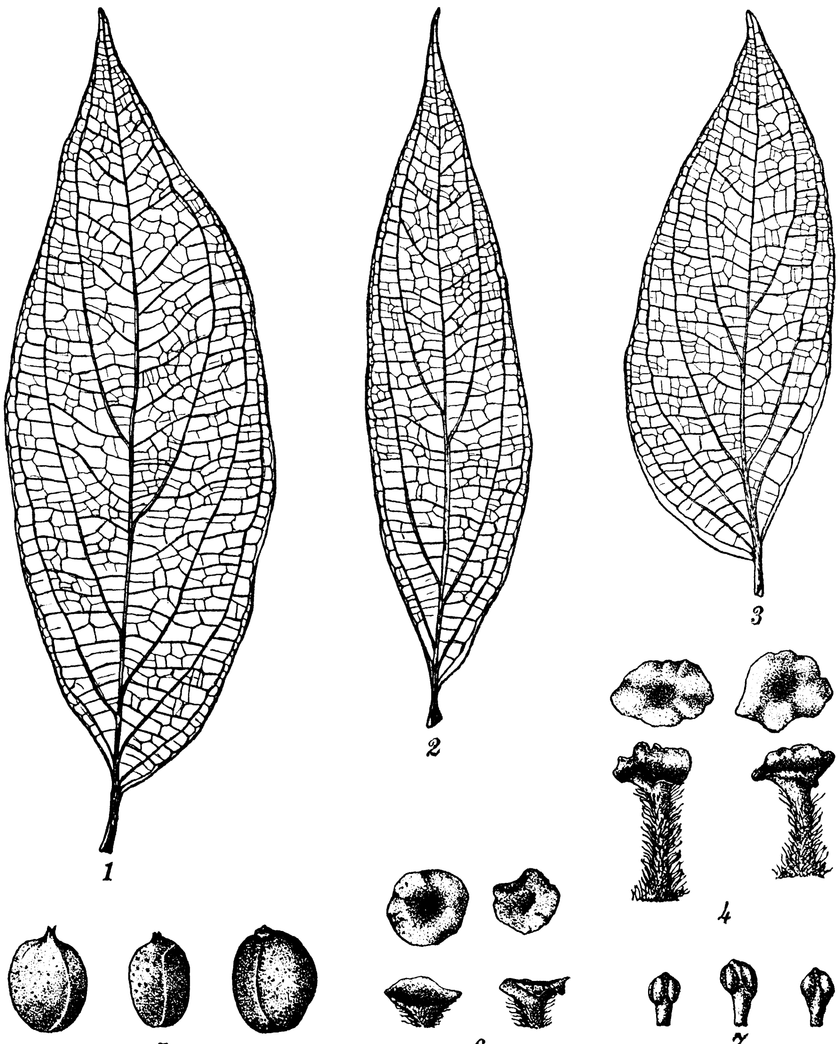


FIG. 28. *Piper parcirameum* C. DC.; *1–3*, leaves, × 0.5; *4*, top and side views of pistillate bracts, × 10; *5*, fruits, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

laterally and obliquely acute, penninerved, nerves about 9 on each side of the midrib, apex acutely acuminate to long acutely attenuate, glabrous above, hirtellous on the nerves beneath, reticulations somewhat obscure above, rather prominent beneath; petioles glabrous, 7 to 15 mm long. Pistillate spikes somewhat abbreviated, 1.3 to 2.5 cm long, 5 to 7 mm in diameter; the peduncles glabrous, 1.3 to 2.7 cm long; rachis villose; bracts long-pedicellate, peltate, 1.5 to 2 mm long, disk subelliptic to suborbicular, 0.75 to 1 mm wide, glabrous, subimbricate, pedicels villose; fruits free, never crowded, base partly embedded in and concrescent with the rachis, oblong to subglobose, 1.75 to 2 mm long, 1 to 1.5 mm in diameter, tubercled all over; stigmas 3, minute, suberect to erect, ovoid, acute. Staminate spikes 2.5 to 3.8 cm long, 2.5 to 2.75 mm in diameter; the peduncles glabrous, 12 to 16 mm long; rachis villose; bracts subsessile, peltate, 0.3 to 0.5 mm long, disk orbicular, 0.75 to 1 mm wide, subimbricate, glabrous; stamens 2, pedicellate, 0.5 to 0.75 mm long, anthers ovoid, tetralocular, 2-valved, connective above the loculi never enlarged, filaments as long as or slightly longer than the anthers, more or less slender, exerted.

MINDANAO, Davao Province, Mount Apo, *Elmer 10899* (type collection), *11274*, *Bur. Sci. 15747 Clemens*. In forests, altitude about 900 meters. Endemic.

Local names: Poruan (Bag.); salimbañgon (Bag.).

Piper celtidiforme Opiz, now placed under a new section (*Penninervia*), was probably derived from a species similar to this. This species has penninerved leaves; the fruits and pistillate bracts most resembling those of *Piper celtidiforme* Opiz. On the other hand, the anthers present features of the *Eupiper* section rather than those of the *Penninervia* section, but also show indications that the connective above the loculi is on the way to enlargement.

25. PIPER COSTULATUM C. DC. Text fig. 29.

Piper costulatum C. DC. in Leafl. Philip. Bot. 3 (1910) 764, Philip. Journ. Sci. 5 (1910) Bot. 420, 11 (1916) Bot. 208, Candollea 1 (1923) 180; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

Piper podandrum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 436, 11 (1916) Bot. 217, Candollea 1 (1923) 188; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branches glabrous, costulate, terete, 0.75 to 1.5 mm in diameter. Leaves thin, membranaceous, with minute brown dots beneath, narrowly linear to ovate-lanceolate or ovate, 4 to 12.5 cm long, 0.4 to 3.3 cm wide, base equilaterally

to subequilaterally repand to cordate, rarely subacute, usually 5- to 7-nerved, sometimes 5- to 7-plinerved, apex narrowed, acute, acumen with minute apiculum, glabrous on both surfaces, reticulations somewhat prominent on both surfaces; petioles glabrous, 4 to 10 mm long. Pistillate spikes abbreviated, oblong to globose, 10 to 13 mm long, 8 to 10 mm in diameter; the

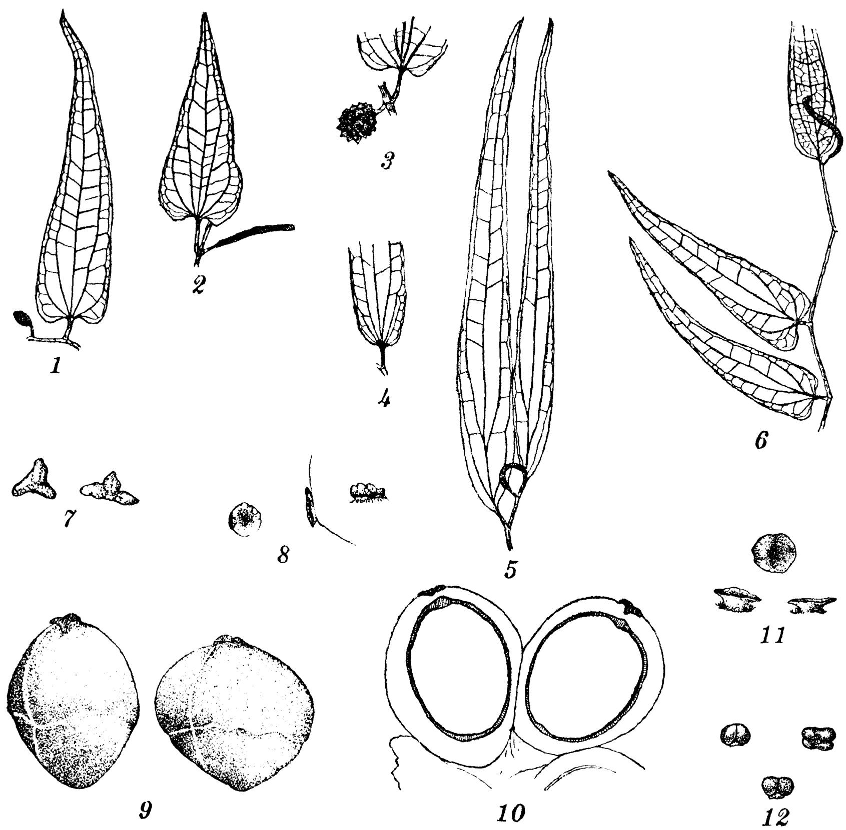


FIG. 29. *Piper costulatum* C. DC.; *1*, leaf with young pistillate spike, × 0.5; *2*, leaf with mature staminate spike, × 0.5; *3*, base of a leaf and mature pistillate spike, × 0.5; *4*, leaf base, × 0.5; *5*, leaves and young staminate spike, × 0.5; *6*, flowering male branch, × 0.5; *7*, top view of stigmas, × 10; *8*, top and side views of pistillate bracts, × 7.5; *9*, fruits, × 7.5; *10*, portion of the transverse section of a mature pistillate spike, × 7.5; *11*, top and side views of staminate bracts, × 10; *12*, stamens, × 10.

peduncles glabrous, 2 to 4.5 mm long; rachis hirtellous; bracts sessile, peltate, disk orbicular, 0.5 to 0.75 mm wide, glabrous; fruits glabrous, free only near the apex, globose to oblong-obovoid, obtuse to rounded, about 3 mm long, 2.5 to 3 mm in diameter; stigmas 3, ovoid, acute, sessile, apical; seeds oblong to globose, about 2.5 mm long. Staminate spikes 2.5 to 4 cm long,

1.5 to 2 mm in diameter; the peduncles glabrous, 2.5 to 5 mm long; rachis hirtellous, bracts subsessile to sessile, peltate, disk orbicular, about 0.5 mm wide, glabrous; stamens 2, subsessile or sessile, about 0.25 mm long, anthers small, subglobose to reniform, bilocular, 2-valved.

LUZON, Cagayan Province, Abulug River, *Bur. Sci. 13838 Ramos:* Isabela Province, Mount Moises, *Bur. Sci. 47337 Ramos and Edaño:* Nueva Viscaya Province, Noso to Imugan, *Bur. Sci. 20071 McGregor;* Caraballo Mountain, *Loher 13745:* Nueva Ecija Province, Mount Umingan, *Bur. Sci. 26450 Ramos and Edaño:* Zambales Province, without definite locality, *For. Bur. 8141 Curran and Merritt* (type collection of *Piper podandrum* C. DC.) ; Tapolao, *Bur. Sci. 5053 Ramos:* Bataan Province, Lamao River, Mount Mariveles, *Elmer 6805* (type collection of *Piper costulatum* C. DC.), *Whitford 129, Williams 415, 743, Merrill 3248, For. Bur. 209 Barnes, 2097, 2394 Borden;* Mount Mariveles, *Copeland 258, Merrill 3768;* Lamao Forest Reserve, *For. Bur. 6221, 6222, 6271 Curran, 1597 Foxworthy:* Rizal Province, Mount Lumutan, *Bur. Sci. 42300 Ramos;* Pamingtingan, *Loher 13150;* without definite locality, *Loher 14229, 14382:* Tayabas Province, Mount Dingalan, *Bur. Sci. 26624 Ramos and Edaño;* Mount Binuang, *Bur. Sci. 28626, 28661, 28746 Ramos and Edaño.* CATANDUANES, Santo Domingo River, *Bur. Sci. 30495 Ramos.* In forests at low and medium altitudes, ascending to 1,500 meters. Endemic.

Local name: Sobo-manók (Tag.).

This species, which is represented by numerous collections, is restricted to Luzon and Catanduanes, and can be readily distinguished by its narrowly linear to ovate-lanceolate or ovate, membranaceous leaves, with a minute apiculum at the apex, and with repand to cordate bases and its abbreviated, oblong to globose pistillate spikes.

26. PIPER CACUMINUM C. DC. Text fig. 30.

Piper cacuminum C. DC. in Leafl. Philip. Bot. 3 (1910) 765, Philip. Journ. Sci. 5 (1910) Bot. 421, Candollea 1 (1923) 182; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

A diœcious vine; the branches glabrous, terete, 2 to 2.5 mm in diameter. Leaves membranaceous, narrowly oblong-lanceolate, 8.5 to 11 cm long, 2 to 2.5 cm wide, base subequilaterally subacute, 5-nerved, apex narrowed, acute, glabrous on both surfaces, reticulations subobscure above, more or less prominent beneath; petioles glabrous, 7 to 10 mm long, in the lower leaves

up to 1.7 cm long. Pistillate spikes abbreviated, oblong, about 1.6 cm long, 1 cm in diameter; the peduncles glabrous, about 1.5 cm long; rachis hirsute; bracts sessile, peltate, 1.2 to 1.5 mm long, disk suborbicular, about 1 mm wide, glabrous; fruits free at the apex only, ovoid, acute, 3.5 to 4 mm long, about 3.5 mm in diameter, glabrous; stigmas 3, rounded, sessile, apical; seeds glabrous, elliptic-ovoid to oblong-subobovoid, 2.5 to 3.5 mm long.

LUZON, Bataan Province, Mount Mariveles, *Elmer 6890* (type in herb. Manila), in the mossy forests near the summit. Endemic.

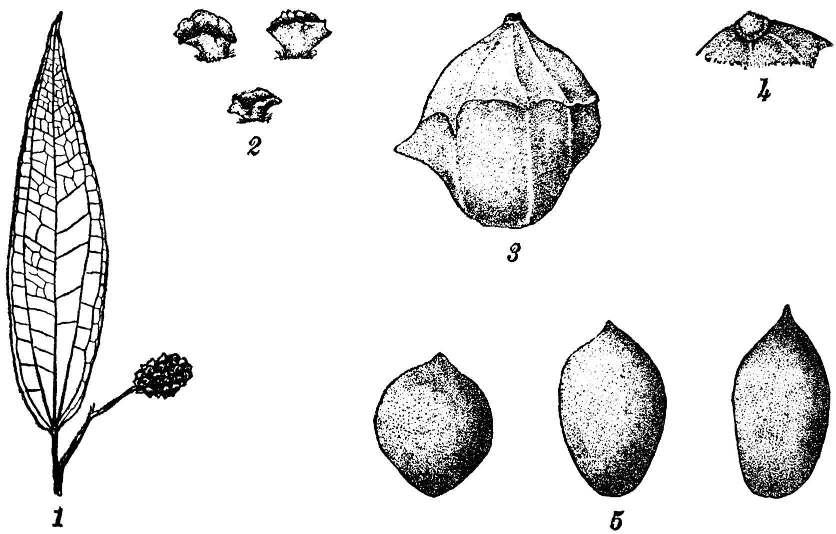


FIG. 30. *Piper cacuminum* C. DC.; *1*, leaf and mature pistillate spike, × 0.5; *2*, side view of pistillate bracts, × 7.5; *3*, fruit, × 7.5; *4*, top view of a fruit, × 7.5; *5*, seeds, × 7.5.

This species is allied to *Piper costulatum* C. DC. but differs in the base of its lamina never being cordate and in its rounded stigmas.

27. PIPER HALCONENSE C. DC. Text fig. 31.

Piper halconense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 422, Candollea 1 (1923) 183, 212; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

Piper cagayanense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 435, 11 (1916) Bot. 217, Candollea 1 (1923) 196; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

An erect diœcious undershrub; the branches glabrous, terete, 1.5 to 2 mm in diameter. Leaves membranaceous, with minute black dots beneath, ovate-lanceolate to elliptic-lanceolate, 6 to

15 cm long, 1.5 to 5.5 cm wide, base equilaterally to subequilaterally acute to subrounded, 7-nerved or 7-plinerved, apex acutely attenuate, glabrous on both surfaces, to somewhat hirtellous on the nerves beneath, reticulations more or less obscure above, prominent beneath; petioles glabrous, 5 to 10 mm long. Pistillate spikes abbreviated, oblong, 1 to 2.3 cm long, 5 to 8 mm in diameter; the peduncles glabrous, 4 to 10 mm long; rachis

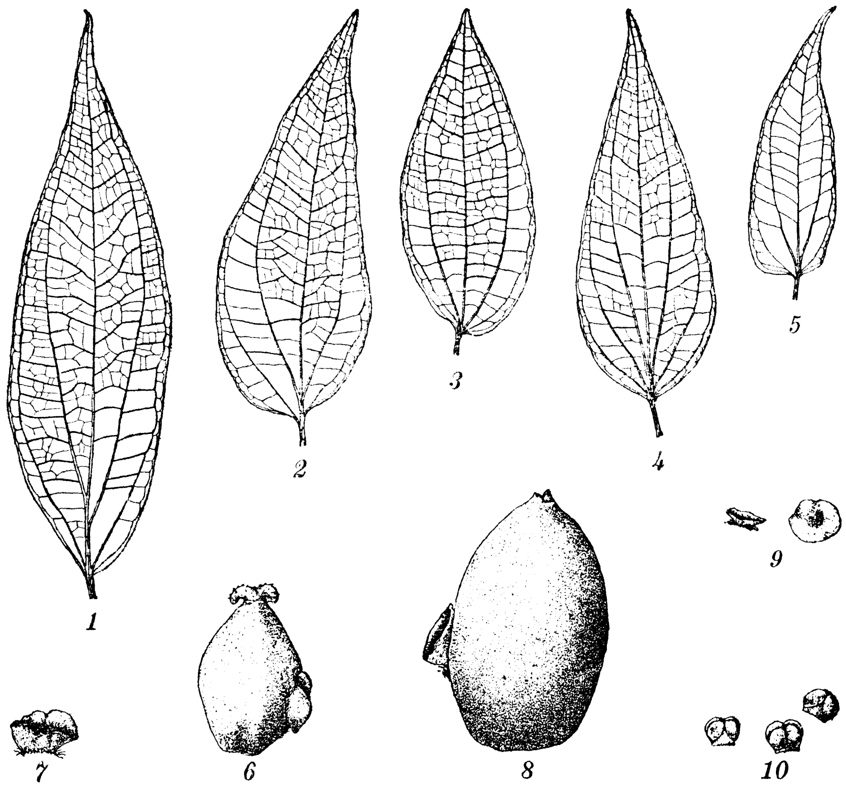


FIG. 31. *Piper halconense* C. DC.; *1–5*, leaves, × 0.5; *6*, young fruit with bract attached, × 10; *7*, side view of a pistillate bract, × 10; *8*, mature fruit with bract attached, × 10; *9*, side and top views of staminate bracts, × 10; *10*, stamens, × 10.

hirsute; bracts sessile, peltate, disk orbicular, 0.75 to 1 mm wide, glabrous; fruits free, base partly embedded in the rachis, oblong to oblong-ovoid, 2.5 to 3 mm long, 1.5 to 2 mm in diameter, glabrous, apex narrowed; stigmas 3, ovoid, sessile, apical; seeds oblong, mucronate, 2 to 2.3 mm long. Staminate spikes usually curved at the apex, 2 to 3 cm long, 1.5 to 2 mm in diameter; the peduncles glabrous, 2.5 to 7 mm long; rachis hirsute; bracts sessile, peltate, about 0.25 mm long, disk orbicular, 0.5 to 0.75

mm wide, glabrous; stamens 2, sessile, about 0.4 mm long, anthers globose to reniform, about 0.4 mm wide.

LUZON, Cagayan Province, Pamplona, *Bur. Sci. 7484 Ramos* (type of *Piper cagayanense* C. DC. in herb. Manila); Tauit, Apiao, *Bur. Sci. 10755 Worcester:* Isabela Province, San Mariano, *Bur. Sci. 46835 Ramos and Edaño:* Apayao Subprovince, Mount Sulu, *Bur. Sci. 28351, 28369 Fénix:* Zambales Province, Iba, *Bur. Sci. 4700 Ramos;* Mount Tapulao, *For. Bur. 8076 Curran and Merritt:* Tayabas Province, Lucban, *Bur. Sci. 47412, 47356 McGregor;* Mount Banahao, *Bur. Sci. 47435 McGregor:* Sorsogon Province, Irosin, Mount Urdaneta, *Elmer 14706, 15778, 17310.* MINDORO, Mount Halcon, *For. Bur. 4393 Merritt* (type of *Piper halconense* C. DC. in herb. Manila), *Merrill 5773, Bur. Sci. 40607, 40725 Ramos and Edaño.* MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13787.* In forests at medium and high altitudes, ascending to 1,500 meters. Endemic.

Local names: Famsaon (Mbo.); tapis-buyañgan (Mang.).

This species is nearly related to *Piper costulatum* C. DC., but has much larger leaves, whose bases are never cordate, and oblong to oblong-ovoid fruits.

28. PIPER ATROSPICUM C. DC. Text fig. 32.

Piper atrospicum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 208, Candollea 1 (1923) 182; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

A diœcious vine; the branches glabrous, slightly costulate, terete, with rather short internodes. Leaves dark brown to black, oblong-ovate, 6 to 7.8 cm long, 2.5 to 3.8 cm wide, base equilaterally to subequilaterally acute to obtuse, 6- or 7-nerved,

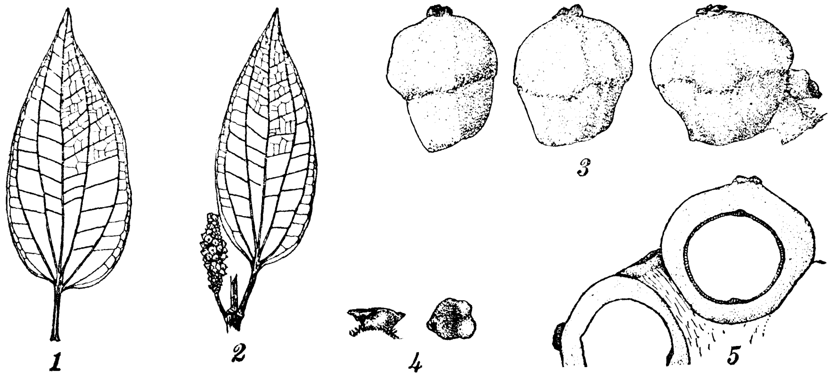


FIG. 32 *Piper atrospicum* C. DC.: *1*, leaf, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, fruits, × 7.5; *4*, side and top views of pistillate bracts, × 7.5; *5*, portion of the transverse section of mature pistillate spike, × 7.5.

apex acutely acuminate, glabrous on both surfaces, reticulations obscure above, prominent beneath; petioles glabrous, 1 to 1.5 cm long. Pistillate spikes abbreviated, black, narrowly oblong, 1.3 to 2.3 cm long, 5 to 6.5 mm in diameter; the peduncles glabrous, 6 to 8 mm long; rachis hirtellous; bracts sessile, peltate, about 0.75 mm long, disk glabrous, orbicular, about 0.75 mm wide; fruits free at the apex only, globose, 2.5 to 3 mm long, about 2 mm in diameter; stigmas 3, ovoid, acute, sessile, apical; seeds globose.

LEYTE, Dagami, *Bur. Sci. 15359 Ramos* (type collection), in mossy forests. Endemic.

This species in its more significant characters is very close to *Piper halconense* C. DC., but differs in its dark-colored, chartaceous leaves, branches, peduncles, and spikes and its globose fruits and seeds.

29. PIPER LONGIVAGINANS C. DC. Text fig. 33.

Piper longivaginans C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 444, 11 (1916) Bot. 219 (incl. forma *b* C. DC.), Candollea 1 (1923) 204; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

Piper magallanesanum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 212, Candollea 1 (1923) 185, 193; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Piper crassinodum C. DC. in Leafl. Philip. Bot. 3 (1910) 780, Philip. Journ. Sci. 5 (1910) Bot. 445, Candollea 1 (1923) 208, 211; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches glabrous, terete, 1.25 to 4 mm in diameter. Leaves membranaceous to chartaceous, dark brown to black when dry, elliptic-lanceolate to elliptic-ovate or oblong-ovate, 7.5 to 18 cm long, 2.2 to 9 cm wide, base subinequilaterally to inequilaterally, rarely equilaterally acute to obtuse, 7-plinerved, apex acutely attenuate to acutely acuminate, glabrous on both surfaces or glabrous above and minutely puberulent on the nerves beneath, reticulations somewhat obscure above, rather prominent beneath; petioles glabrous to sparsely hirtellous, vaginate their whole length, 3 to 9 mm long, in the lower leaves up to 13 mm long. Pistillate spikes oblong, 1.5 to 2.5 cm long, 6 to 10 mm in diameter; the peduncles glabrous to sparsely hirtellous, 8 to 14 mm long; rachis hirtellous; bracts sessile, peltate, disk glabrous, orbicular, about 0.75 mm wide; fruits glabrous, free, base partly embedded in and concrescent with the rachis, oblong-obovoid, acute, 3 to 3.5 mm long, 2.25 to 2.5 mm in diameter; seeds oblong, 2.25 to 2.5 mm long, umbonate; stigmas 3 or 4, oblong, short, sessile, apical. Staminate

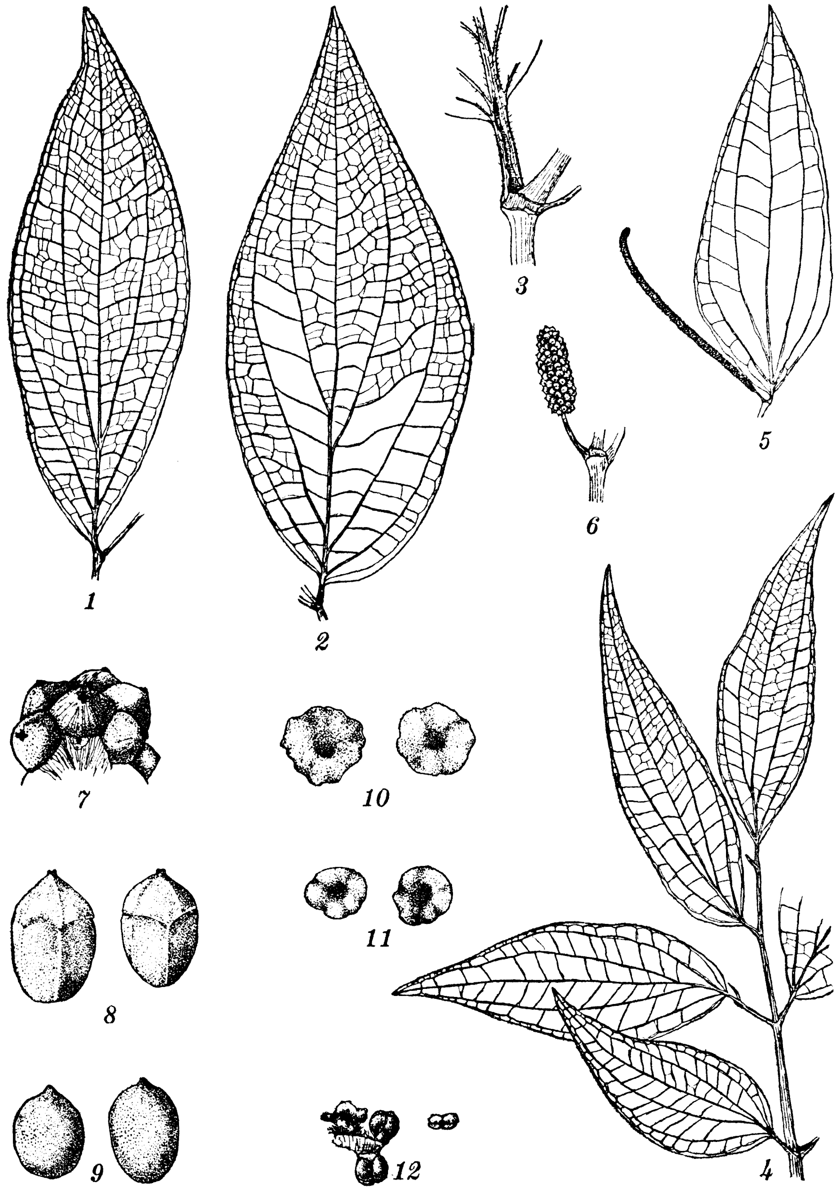


FIG. 33. *Piper longivaginans* C. DC.; *1–2*, leaves, × 0.5; *3*, detail of petiole, enlarged; *4*, branch, × 0.5; *5*, leaf and mature staminate spike, × 0.5; *6*, mature pistillate spike, × 0.5; *7*, apex of the pistillate spike, × 2.25; *8*, fruits, × 5; *9*, seeds, × 5; *10*, top view of pistillate bracts, × 10; *11*, top view of staminate bracts, × 10; *12*, side view of staminate bract and stamens, × 10.

spikes recurved, black when dry, 3 to 7.5 cm long, 1.75 to 2 mm in diameter; the peduncles glabrous to sparsely hirtellous, 3 to 9 mm long; rachis hirtellous; bracts sessile, peltate, disk glabrous, orbicular, 0.5 to 0.6 mm wide; stamens 2, subsessile, anthers reniform, tetralocular, 2-valved.

LUZON, Nueva Ecija Province, Mount Umingan, *Bur. Sci. 26496 Ramos and Edaño:* Rizal Province, Montalban, *Loher 12141;* Balacbac, *Loher 13021;* Pamingtingan, *Loher 13505;* Mount Lumutan, *Bur. Sci. 42252 Ramos, 29669, 29720 Ramos and Edaño;* Mount Irid, *Bur. Sci. 41864 Ramos, 48510, 48512 Ramos and Edaño;* Mount Tokduanbanog, *Bur. Sci. 48607 Ramos and Edaño:* Laguna Province, Mount San Cristobal, *Gates 6432, Juliano 1079, 1087;* Mount Banahao, *Bur. Sci. 6069 Robinson* (type collection of *Piper longivaginans* C. DC.), *27972 Ocampo, Quisumbing 1248, Baker 2423:* Tayabas Province, Lucban, *Elmer 8042* (type collection of *Piper crassinodum* C. DC.) ; Mount Binuang, *Bur. Sci. 28723, 28797 Ramos and Edaño;* Mount Tulaog, *Bur. Sci. 29094, 29120 Ramos and Edaño:* Camarines Sur Province, Mount Isarog, *Bur. Sci. 22057 Ramos.* SIBUYAN, Mount Giting-giting, *Elmer 12313 p. p.* (type collection of *Piper magallanesanum* C. DC.), *12313 p. p.* (type collection of *Piper longivaginans* C. DC. forma *b* C. DC.). In forests at medium and high altitudes, ascending to 2,500 meters. Endemic.

Local names: Bayóng-ukaí (Bik.) ; maraklít-salusalú (Ig.) ; salusalong-bata (Ig.).

The alliance of this species is with *Piper halconense* C. DC., from which it is distinguished by its dark brown to black leaves, and black spikes and its petioles being vaginate their whole length. Perhaps this species is allied to *Piper nigrescens* Blume.

30. **PIPER DELICATUM C. DC.** Text fig. 34.

Piper delicatum C. DC. in Leafl. Philip. Bot. 3 (1910) 778, Philip. Journ. Sci. 5 (1910) Bot. 444 (incl. var. *glabrum* C. DC.), 11 (1916) Bot. 219 (incl. forma *b* C. DC.), Candollea 1 (1923) 193, 203; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper polisanum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 209, Candollea 1 (1923) 183; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

A diœcious, slender vine; the young branches usually hirtellous, older ones glabrous, terete, pale, 1 to 2.5 mm in diameter. Leaves chartaceous, with brown to black dots beneath, narrowly ovate-lanceolate to narrowly elliptic-lanceolate, 3 to 9 cm long, 0.6 to 2 cm wide, base equilaterally to subequilaterally acute, 5-plinerved, apex acutely acuminate, glabrous on both surfaces,

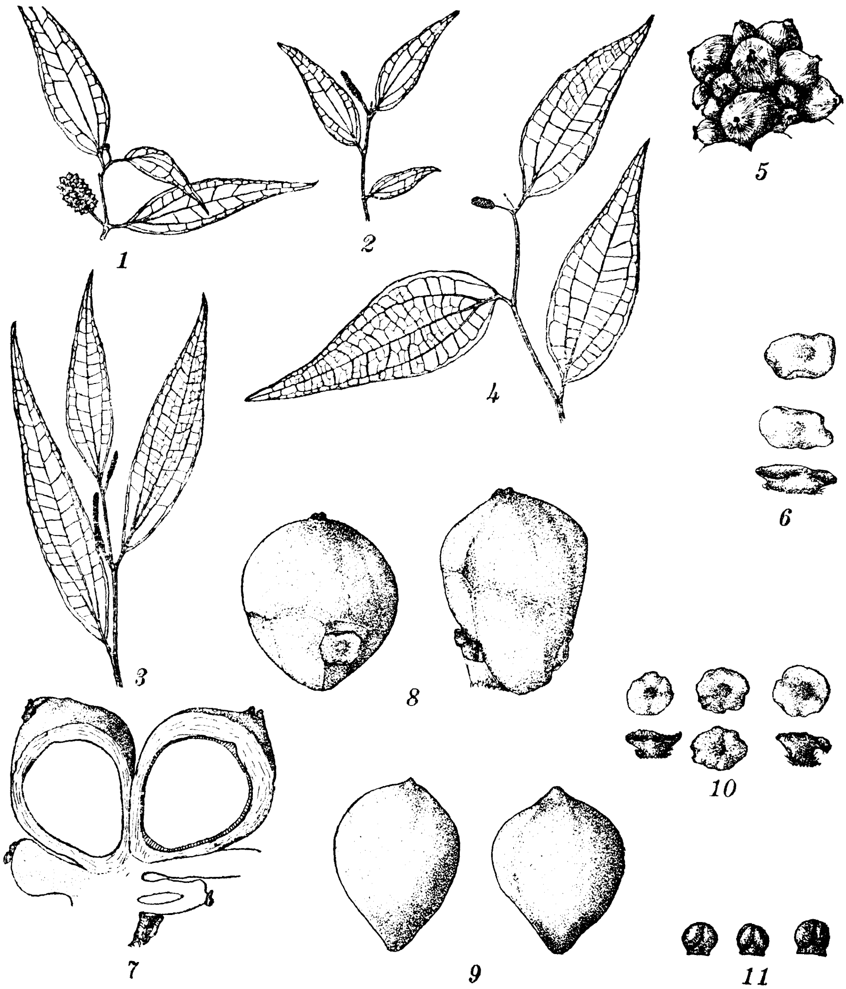


FIG. 34. *Piper delicatum* C. DC.; *1*, branch with mature pistillate spike, × 0.5; *2*, flowering branch of a male plant, × 0.5; *3*, flowering branch of a male plant, × 0.5; *4*, flowering branch of a female plant, × 0.5; *5*, apex of a pistillate spike, × 2.25; *6*, top and side views of pistillate bracts, × 10; *7*, portion of the transverse section of a mature pistillate spike, × 7.5; *8*, fruits with bracts attached, × 7.5; *9*, seeds, × 7.5; *10*, top and side views of staminate bracts, × 10; *11*, stamens, × 10.

or somewhat puberulent on the nerves beneath, reticulations somewhat obscure above, prominent beneath; petioles glabrous to sparsely hirtellous, 4 to 11 mm long, in the lower leaves up to 22 mm long, vaginate at the base. Pistillate spikes abbreviated, oblong, erect, 9 to 20 mm long, 6 to 9 mm in diameter; the peduncles glabrous, 6 to 17 mm long; rachis hirtellous; bracts sessile, peltate, disk glabrous, suborbicular, 0.75 to 1 mm wide; fruits free, base partly embedded in and concrescent with the

rachis, obovoid, subacute, 2 to 3.5 mm long, 1.75 to 2.75 mm in diameter; stigmas 3, rarely 4, ovoid, acute, sessile, apical; seeds glabrous, smooth, subovoid-elliptic, subacute, 2.25 to 3.25 mm long. Staminate spikes erect, 13 to 20 mm long, 1.5 to 2.5 mm in diameter; the peduncles glabrous or rarely hirtellous, 3 to 5 mm long; rachis hirtellous; bracts subsessile, peltate, 0.25 to 0.4 mm long, disk glabrous, orbicular, 0.6 to 0.75 mm wide; stamens 2, subsessile, anthers globose, 2-valved.

LUZON, Ilocos Norte Province, Mount Palimlim, *Bur. Sci. 33281 Ramos:* Lepanto Subprovince, Mount Data, *Merrill 4494, For. Bur. 15997 Bacani, Bur. Sci. 40278 Ramos and Edaño:* Bontoc Subprovince, Malamey, *Vanoverbergh 1140;* Bauco, *Vanoverbergh 1167;* Mount Masapilid, *Bur. Sci. 37938, 37962 Ramos and Edaño;* Mount Caua, *Bur. Sci. 38069 Ramos and Edaño:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19817* (type collection of *Piper polisanum* C. DC.), *19815, 19816 McGregor:* Benguet Subprovince, Baguio, *Elmer 8583* (type collection of *Piper delicatum* C. DC.); Mount Santo Tomas, *Williams 1216* (type of *Piper delicatum* C. DC. var. *glabrum* C. DC. in herb. Manila), *For. Bur. 11092 Whitford, 15604 Curran, Bur. Sci. 5403 Ramos, Merrill 11718, McClure 16031;* Pauai, *Clemens 9160, Bur Sci. 4454 Mearns, 8497 McGregor, 31693 Santos;* Mount Tonglon, *For. Bur. 4964 Curran, Philip. Pl. 750 Merrill, Merrill 4820, Bur. Sci. 5461 Ramos.* In forests, usually at high altitudes, to about 2,400 meters. Endemic.

Local names: Maniniak (Ig.); umum (Ig.).

This species is certainly close to *Piper halconense* C. DC., but differs in its erect pistillate and staminate spikes, the latter never curved at the apex, its obovoid fruits and seeds, and also in the size, form, and venation of the leaves, which are usually smaller and narrow, and the bases of the lamina acute, and 5-plinerved. The form with smaller leaves bears resemblance to *Piper curtifolium* C. DC. but differs in the form and venation of the lamina and the subsessile stamens.

31. PIPER CURTIFOLIUM C. DC. Text fig. 35.

Piper curtifolium C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 421, Candollea 1 (1923) 181; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches glabrous, smooth, older ones lenticellate and rugose, terete, 1 to 3 mm in diameter. Leaves membranaceous to chartaceous, with few scattered black dots, usually dark colored, ovate to elliptic-ovate, 2.5 to 6.5 cm long, 1 to 3.5 cm wide, base equilaterally to subequilaterally acute,

sometimes obtuse, 5- to 7-nerved, apex shortly and acutely acuminate, glabrous on both surfaces, reticulations subobscure to obscure above, prominent beneath; petioles glabrous, 3 to 12 mm long, in the lower leaves up to 30 mm long. Pistillate spikes abbreviated, oblong, 8 to 13 mm long, 5 to 7 mm in diameter; the peduncles glabrous, 4.5 to 7 mm long; rachis hirtellous; bracts subsessile, peltate, 0.75 to 1 mm long, disk glabrous, orbicular, 0.75 to 1 mm wide; fruits partly embedded in the rachis, globose to subglobose, subacute, 2 to 3 mm long, 1.75 to 2 mm in diameter, glabrous; stigmas 3 or 4, ovoid, acute, sessile, apical. Staminate spikes 1.8 to 2.2 cm long, 1 to 1.5 mm in diameter; the peduncles glabrous, about 5 mm long; rachis hirtellous; bracts subpedicellate, peltate, 0.5 to 0.75 mm long, disk glabrous, orbicular, 0.5 to 0.75 mm wide; stamens 2, sessile, anthers subglobose, bilocular, 2-valved.

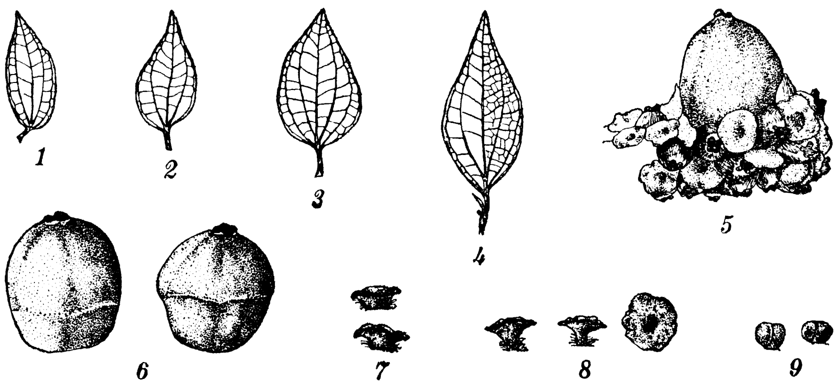


FIG. 35. *Piper curtifolium* C. DC.; *1–4*, leaves, × 0.5; *5*, portion of pistillate spike, × 7.5; *6*, fruits, × 7.5; *7*, side view of pistillate bracts, × 7.5; *8*, side and top views of staminate bracts, × 10; *9*, stamens, × 10.

LUZON, Ilocos Norte, Mount Palimlim, *Bur. Sci. 33363 Ramos:* Abra Province, Mount Paraga, *Bur. Sci. 7107 Ramos* (type of *Piper curtifolium* C. DC. in herb. Manila): Bontoc Subprovince, Mount Puquis, *Bur. Sci. 37844 Ramos and Edaño:* Benguet Subprovince, Mount Pulogloco, *Bur. Sci. 40406 Ramos and Edaño:* Rizal Province, Mount Lumutan, *Bur. Sci. 42315 Ramos:* Tayabas Province, Mount Binuang, *Bur. Sci. 28781, 28664 Ramos and Edaño.* In forests at higher altitudes, ascending to 2,250 meters. Endemic.

A species belonging in the group with *Piper halconense* C. DC. and *Piper delicatum* C. DC. and being closely allied to *Piper delicatum* C. DC., differing from the last by the venation and form of its lamina and its sessile stamens.

32. PIPER VARIBRACTEUM C. DC. Text fig. 36.

Piper varibracteum C. DC. in Leafl. Philip. Bot. 3 (1910) 764, Philip. Journ. Sci. 5 (1910) Bot. 421, 11 (1916) Bot. 208, Candollea 1 (1923) 182; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper striatum C. DC. in Leafl. Philip. Bot. 3 (1910) 776, Philip. Journ. Sci. 5 (1910) Bot. 441, Candollea 1 (1923) 279; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15; non Vahl (1804) nec C. DC. (1871-73).

Piper maincaw C. DC. in Candollea 1 (1923) 209.

A diœcious vine; the branches glabrous, terete, 1.25 to 2 mm in diameter. Leaves chartaceous to subcoriaceous, elliptic-ovate, 6 to 8.2 cm long, 3 to 4.5 cm wide, base subinequilaterally acute,

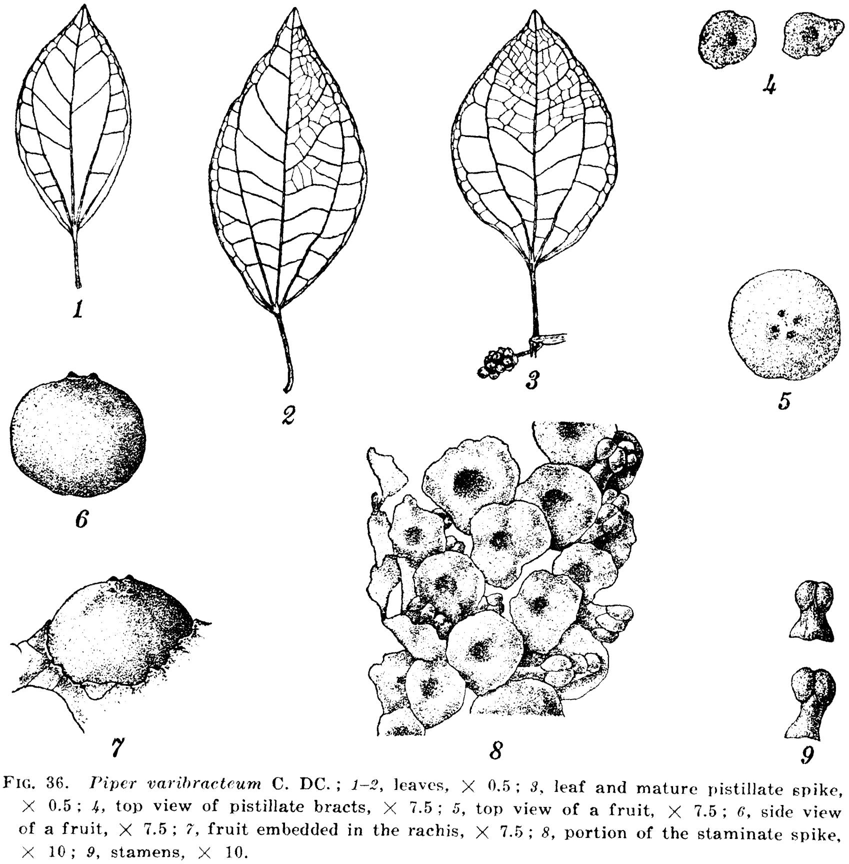


FIG. 36. *Piper varibracteum* C. DC.; *1–2*, leaves, × 0.5; *3*, leaf and mature pistillate spike, × 0.5; *4*, top view of pistillate bracts, × 7.5; *5*, top view of a fruit, × 7.5; *6*, side view of a fruit, × 7.5; *7*, fruit embedded in the rachis, × 7.5; *8*, portion of the staminate spike, × 10; *9*, stamens, × 10.

5-nerved to 5-plinerved, apex shortly and obtusely, obscurely acuminate, glabrous on both surfaces, reticulations more or less prominent on both surfaces; petioles glabrous, 1.5 to 2.5 cm long in the female, 2.5 to 8 mm long in the male. Pistillate spikes abbreviated, ovoid, 0.8 to 1 cm long, 5 to 7 mm in dia-

meter; the peduncles glabrous, 1 to 1.3 cm long; rachis sparsely pilose; bracts sessile, peltate, disk glabrous, suborbicular, 0.75 to 1 mm wide; fruits free only at the apex, globose, 2.25 to 2.5 mm long, 2.5 to 3 mm in diameter; stigmas 4, distant, free, ovoid, acute, sessile, apical. Staminate spikes 3.5 to 6 cm long, 1.5 to 2 mm in diameter; the peduncles glabrous, 10 to 14 mm long; rachis sparsely pilose; bracts sessile, peltate, disk glabrous, somewhat fleshy, rounded-obovate to orbicular, 0.75 to 1 mm wide; stamens 2, pedicellate, 0.75 to 1 mm long, anthers globose, tetralocular, 4-valved, filaments oblong.

MINDANAO, Davao Province, Mount Apo, *Elmer 11998* (type collection of *Piper varibracteum* C. DC.), *11764* (type collection of *Piper striatum* C. DC.), *11162*. In forests at medium altitudes. Endemic.

Local names: Manikatápi, miaukau (Bag.).

A species belonging in the group with *Piper delicatum* C. DC. but near *Piper curtifolium* C. DC., differing from the latter by its larger leaves, globose fruits, variable bracts, and pedicellate stamens.

33. PIPER MINDORENSE C. DC. Text fig. 37.

Piper mindorense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 423, Candollea 1 (1923) 183; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

A diœcious vine; the young branches densely hirtellous, the older ones glabrous, 1.25 to 2 mm in diameter. Leaves chartaceous, ovate, 4.5 to 5.5 cm long, 3 to 3.5 cm wide, base equilaterally rounded, 7-nerved, apex shortly and acutely acuminate, glabrous and dark brown above, conspicuously and densely hirtellous on the nerves beneath, reticulations obscure above, prominent beneath; petioles hirtellous, 5 to 10 mm long. Pistillate spikes abbreviated, subglobose, about 1 cm long, 0.7 cm in diameter; the peduncles hirtellous, 5 to 6 mm long; rachis puberulent; bracts sessile, peltate, disk glabrous, orbicular, about 0.75 mm wide; fruits free only at the apex, ellipsoid, umbonate,

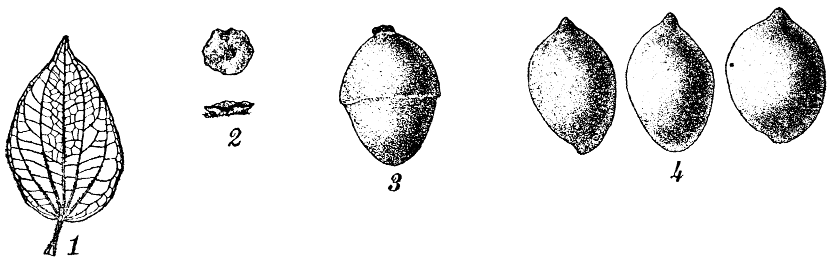


FIG. 37. *Piper mindorense* C. DC.; *1*, leaf, × 0.5; *2*, top and side views of pistillate bracts, × 7.5; *3*, fruit, × 7.5; *4*, seeds, × 8.

about 2.5 mm long, 1.75 mm in diameter; stigmas 3, oblong, sessile, apical; seeds subglobose to elliptic-ovoid, about 2.25 mm. long, apex conspicuously umbonate.

MINDORO, Mount Halcon, *For. Bur. 4474 Merritt* (type in herb. Manila). Endemic.

This species most nearly approaches *Piper curtifolium* C. DC., but differs in many respects; for instance, in its ovate leaves, with rounded bases, its hirtellous nerves, its ellipsoid fruits, and its conspicuously umbonate seeds.

34. PIPER OVATIBACCUM C. DC. Text fig. 38; Plate 17, fig. 7.

Piper ovatibaccum C. DC. in Leafl. Philip. Bot. 3 (1910) 782, Philip. Journ. Sci. 5 (1910) Bot. 445 (incl. forma *b* C. DC.), 11 (1916) Bot. 220, Candollea 1 (1923) 205; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

Piper robinsonii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 445, Candollea 1 (1923) 206; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branchlets villose, terete, the branches glabrous, 1.25 to 2.5 mm in diameter, lenticels prominent. Leaves membranaceous to chartaceous, with brown dots beneath, narrowly elliptic-lanceolate to ovate, 5.5 to 13 cm long, 1.2 to 6.4 cm wide, base subequilaterally acute to obtuse, 5- to 7-plinerved, apex acutely acuminate, pilose on both surfaces, reticulations somewhat obscure above, prominent beneath; petioles pilose to densely pilose, 5 to 15 mm long, in the lower leaves up to 45 mm long. Pistillate spikes abbreviated, oblong, 1 to 2.2 cm long, 6 to 10 mm in diameter; the peduncles glabrous or sparingly pilose, 3 to 8 mm long; rachis pilose; bracts sessile, peltate, disk glabrous, orbicular, about 0.75 mm wide; fruits free, base partly embedded in and concrescent with the rachis, oblong-obovoid to obovoid, subacute, 2.75 3.25 mm long, 1.75 to 2.25 mm in diameter; stigmas 3, ovoid, acute, sessile, apical; seeds glabrous, oblong to obovoid, subacute, 2.5 to 3 mm long. Staminate spikes suberect, usually curved at the apex, 3.5 to 6.5 cm long, 1.25 to 2 mm in diameter; the peduncles glabrous or sparsely pilose, 2 to 6 mm long; rachis densely pilose; bracts sessile, peltate, disk glabrous, orbicular, 0.6 to 0.75 mm wide; stamens 2, sessile, anthers ovoid, 2-valved.

LUZON, Rizal Province, Mount Irig, *Bur. Sci. 41998 Ramos;* Balacbac, *Loher 13079:* Laguna Province, Santa Maria, *Bur. Sci. 42519 Taguibao;* Paete, *For. Bur. 26798 Mabesa, Baker 3165;* San Antonio, *Philip. Pl. 1101 Ramos, Bur Sci. 16643,*

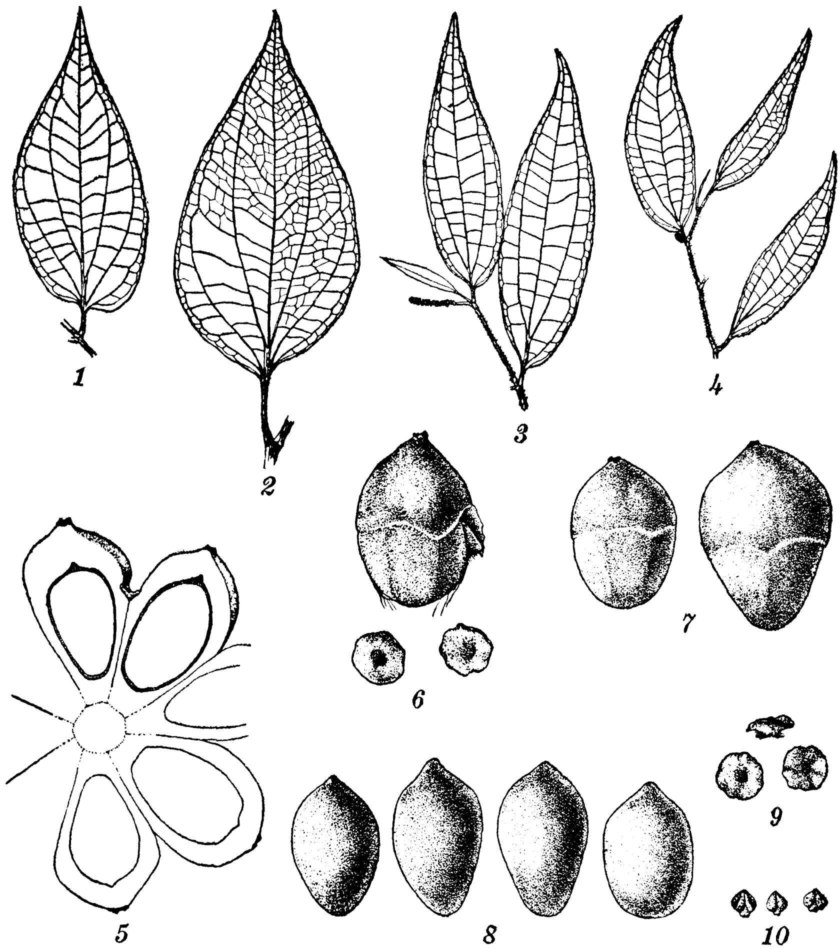


FIG. 38. *Piper ovatibaccum* C. DC.; *1–2*, leaves, × 0.5; *3*, branchlet with young staminate spike, × 0.5; *4*, branchlet with young pistillate spike, × 0.5; *5*, portion of the transverse section of a mature pistillate spike, × 7.5; *6*, fruit with bract attached and top view of pistillate bracts, × 7.5; *7*, fruits, × 7.5; *8*, seeds, × 7.5; *9*, side and top views of staminate bracts, × 10; *10*, stamens, × 10.

20128, 20418, 20486 Ramos; Mount Banahao, *Bur. Sci. 6065* (type of *Piper robinsonii* C. DC. in herb. Manila), *6089, 9755, 9759 Robinson, 2460 Foxworthy, For. Bur. 8016 Curran and Merritt, Quisumbing 1253, 1280, Calvin 316, Juliano 1086a:* Tayabas Province, Lucban, *Elmer 7888* (type collection of *Piper ovatibaccum* C. DC.); Infanta, *Bur. Sci. 9355 Robinson;* Mount Binuang, *Bur Sci. 28772 Ramos and Edaño:* Camarines Province, Mount Bagacay, *Bur. Sci. 33860 Ramos and Edaño:* Sor-

sogon Province, Mount Kililibong, *Bur. Sci. 23510 Ramos.* CATANDUANES, Mount Mareguidon, *Bur. Sci. 30516 Ramos.* MINDORO, Mount Halcon, *Merrill 5645, Bur. Sci. 40729 Ramos and Edaño.* PANAY, Capiz Province, Jamindan, *Bur. Sci. 31218 Ramos and Edaño.* LEYTE, Dagami, *Bur. Sci. 15363 Ramos;* Jaro, Buenavista, *Wenzel 524, 590, 602, 636, 735, 960, 982, 1114, 1115, 1162.* MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13687:* Bukidnon Province, Kabaritan, *Rola 68;* Mount Dalirig, *Bur. Sci. 21446 Escritor;* Mount Candoon, *Bur. Sci. 38776 Ramos and Edaño;* Agusan River, near Tangkulan, *Bur. Sci. 39104 Ramos and Edaño:* Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n.* In forests at medium altitudes, ascending to 1,075 meters. Endemic.

Local names: Búyo-háyo (P. Bis.); dumá-dínayan (Lan.); litlít (Tag.); litlít-matsíng (Tag.); mapoua (Buk.).

The species in its inflorescence and form of the leaves resembles *Piper halconense* C. DC., but differs in the conspicuous pubescence on its vegetative organs and in its ovoid anthers.

35. **PIPER RAMOSII C. DC.** Text fig. 39.

Piper ramosii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 426, 11 (1916) Bot. 211, Candollea 1 (1923) 206; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

A diœcious vine; the branchlets densely hirsute, older branches glabrous, terete, pale when dry, 1.5 to 2.5 mm in diameter. Leaves membranaceous to chartaceous, narrowly oblong-ovate to ovate-lanceolate, 6.5 to 12 cm long, 1.5 to 3 cm wide, base inequilaterally cordate-auriculate, 5- to 7-plinerved, apex narrowed, acute, hirtellous on both surfaces, reticulations more or less prominent beneath; petioles densely hirsute, 2 to 6 mm long, in the lower leaves up to 20 mm long. Pistillate spikes suberect, somewhat abbreviated, oblong, 1.5 to 2 cm long, 6 to 10 mm in diameter; the peduncles hirsute, 4 to 6 mm long; rachis hirsute; bracts subsessile, peltate, disk glabrous, nearly orbicular to ovate, about 1 mm wide, pedicel hirsute; fruits with base partly embedded in and concrescent with the rachis, glabrous, angled, obovoid, 3.5 to 4 mm long, 2.5 to 3 mm in diameter; stigmas 3, linear, acute, sessile, apical; seeds obovoid, 3 to 3.5 long. Staminate spikes 3 to 4.5 cm long, 1.5 to 2 mm in diameter; the peduncles hirsute, 5 to 7 mm long; rachis hirsute; bracts subsessile or sessile, peltate, disk glabrous, orbicular, about 0.5 mm wide; stamens 2, sessile, anthers small, reniform, tetralocular, 2-valved.

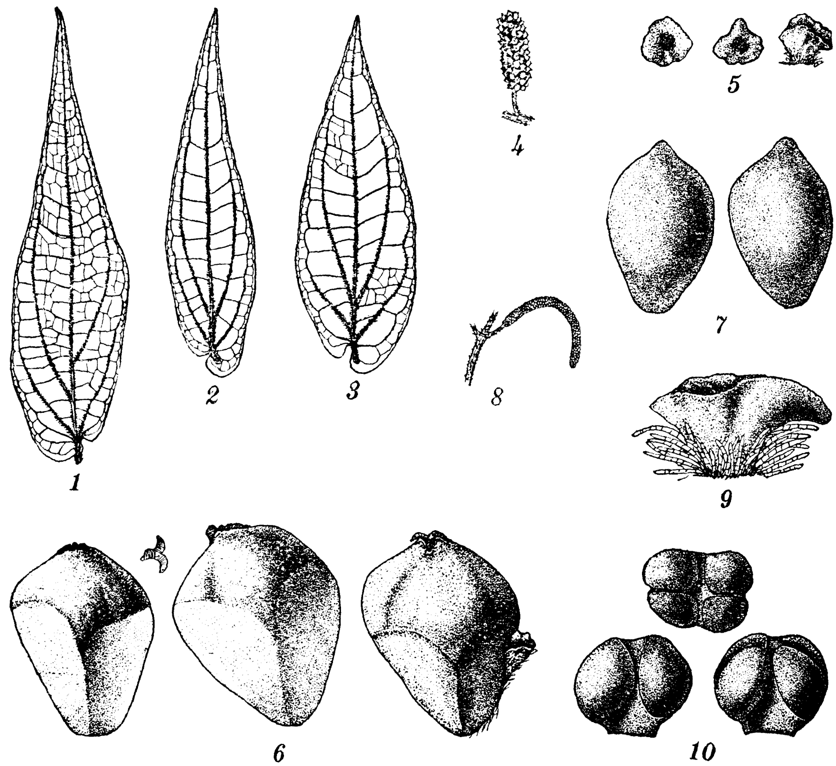


FIG. 39. *Piper ramosii* C. DC.; *1–3*, leaves, × 0.5; *4*, mature pistillate spike, × 0.5; *5*, top and side views of pistillate bracts, × 7.5; *6*, fruits, × 7.5; *7*, seeds, × 7.5; *8*, staminate spike, × 0.5; *9*, side view of staminate bract, × 40; *10*, top and side views of stamens, × 40.

LUZON, Rizal Province, Bosoboso, *Bur. Sci. 1755 Ramos* (type collection); San Isidro, *Bur. Sci. 13397, 24932 Ramos;* Antipolo, *Bur. Sci. 22279 Ramos;* San Andales, *Bur. Sci. 19149 Reillo;* Mount Lumutan, *Bur. Sci. 29779, 29645 Ramos and Edaño;* Montalban, *Loher 12099, 12137.* In forests at low and medium altitudes. Endemic.

This species is nearest to *Piper ovatibaccum* C. DC., but differs conspicuously in its auriculate leaves and reniform anthers.

36. PIPER FUSCINERVUM sp. nov. Text fig. 40; Plate 7.

Frutex dioicus, scandens; ramulis fuscis, nigrescentibus, junioribus dense hirsutis, vetustioribus glabris, 1.5 ad 3 mm diametro; foliis membranaceis ad subchartaceis, oblongo-ovatis ad ovatis, 7.5 ad 12 cm longis, 3.5 ad 4.5 cm latis, basi inequilateralibus, cordatis-auriculatis, 5- to 7-plinerviis, apice acute

acuminatis, utrinque hirtellis, fuscis, nigrescentibus; petiolo 4 ad 9 mm longo, dense hirsuto; spicis ♀ subabbreviatis, oblongis, 1.5 ad 2 cm longis, 6 ad 7 mm diametro; pedunculis hirsutis, 10 ad 18 mm longis; bracteis sessilibus, peltatis, peltis orbicularis, glabris; baccis liberis, partim immersis, globoso-ovoideis, 2 ad 2.25 mm longis, 1.75 ad 2 mm diametro; stigmatibus 3 vel 4, ovoideis, acutis, sessilibus; spicis ♂ erectis, 2.5 ad 4 cm longis, 1 ad 1.25 mm diametro; pedunculis glabris; rachis hirsutis; bracteis sessilibus, peltatis, peltis orbicularis, glabris; staminibus 2, antheris reniformibus, 2-valvatis.

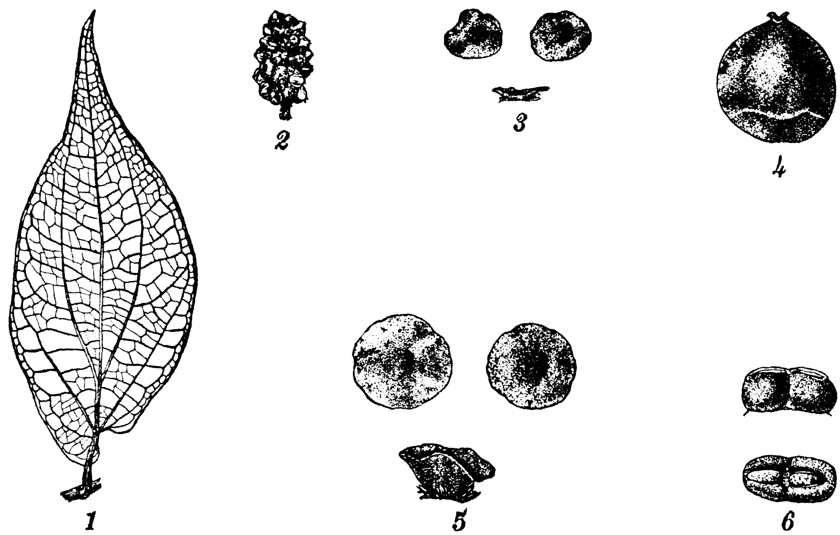


FIG. 40. *Piper fuscinervum* sp. nov.; *1*, leaf, × 0.5; *2*, mature pistillate spike, natural size; *3*, top and side views of staminate bracts, × 10; *4*, fruit, × 10; *5*, top and side views of pistillate bracts, × 10; *6*, stamens, × 40.

A diœcious vine; the branchlets densely hirsute, the older branches glabrous, terete, brown to black when dry, 1.5 to 3 mm in diameter. Leaves membranaceous to subchartaceous, with minute black dots beneath, oblong-ovate to ovate, 7.5 to 12 cm long, 3.5 to 4.5 cm wide, base inequilaterally cordate-auriculate, 5- to 7-plinerved, apex acutely acuminate, hirtellous on both surfaces, reticulations black, prominent beneath; petioles densely hirsute, 4 to 9 mm long, in the lower leaves up to 23 mm long. Pistillate spikes somewhat abbreviated, oblong, 1.5 to 2 cm long, 6 to 7 mm in diameter; the peduncles hirsute, 10 to 18 mm long; rachis hirsute; bracts sessile, peltate, disk, glabrous, orbicular, about 1 mm wide; fruits partly embedded in

and concrescent with the rachis, red, glabrous, globose-ovoid, 2 to 2.25 mm long, 1.75 to 2 mm in diameter; stigmas 3 or 4, ovoid, acute, sessile, apical. Staminate spikes 2.5 to 4 cm long, 1 to 1.25 mm in diameter; the peduncles glabrous, 6 to 8 mm long; rachis hirsute; bracts sessile, peltate, disk glabrous, orbicular, 0.5 to 0.75 mm wide; stamens 2, sessile, anthers small, reniform, bilocular, 2-valved.

PANAY, Capiz Province, Mount Madiias, *Bur. Sci. 30660, 30663, 30664, 30691 Ramos and Edaño;* Jamindan, *Bur. Sci. 30980, 31218 Ramos and Edaño;* Libacao, *Bur. Sci. 35324, 35345, 35380* (type in herb. Manila), *35510 Martelino and Edaño;* Mount Bulinao, *Bur. Sci. 35750 Martelino and Edaño.* MINDANAO, Bukidnon Province, Sumilao, *Bur. Sci. 15788 Fénix;* Tangkulan, *Bur. Sci. 39104 Ramos and Edaño.* In forests at low and medium altitudes.

Local name Tagpúan (Buk.).

Without doubt a species allied to *Piper ramosii* C. DC., but with much larger leaves and longer peduncles, which are usually brown to black.

37. PIPER BETLE Linn. Text figs. 41 and 42; Plate 17, fig. 8.

Piper betle LINN., Sp. Pl. (1753) 28, ed. 2 (1762) 40; BLANCO, Fl. Filip. (1837) 22, ed. 2 (1845) 16, ed. 3, 1 (1877) 30, *t. 12;* F.-VILL., Novis. App. (1880) 175; C. DC., Prodr. 16^1 (1869) 359, Philip. Journ. Sci. 5 (1910) Bot. 431 (incl. formæ *b* and *c* C. DC.), 11 (1916) Bot. 215, Leafl. Philip. Bot. 3 (1910) 447, Candollea 1 (1923) 187, 189, 195; MERR., Fl. Manila (1912) 170, Sp. Blancoanae (1918) 119, Enum. Philip. Fl. Pl. 2 (1923) 4.

Piper siriboa LINN., Sp. Pl. ed. 2 (1762) 41; BLUME, Verh. Bat. Genoots. 11 (1826) 208, *t. 24.*

Chavica siriboa MIQ., Syst. Pip. (1843) 224, Fl. Ind. Bat. 1^2 (1858–59) 438.

Piper anisumolens BLANCO, Fl. Filip. (1837) 23; HASSK., Flora 47 (1864) 59.

Piper anisodorum BLANCO, Fl. Filip. ed. 2 (1845) 16, ed. 3 1 (1877) 31, *t. 362.*

Chavica betle MIQ., Syst. Pip. (1843) 228, Fl. Ind. Bat. 1^2 (1858–59) 439.

Piper philippinense C. DC., Prodr. 16^1 (1869) 353; F.-VILL., Novis. App. (1880) 175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219.

Piper bathycarpum C. DC. in Perk. Frag. Fl. Philip. (1905) 153, Philip. Journ. Sci. 5 (1910) Bot. 434, Candollea 1 (1923) 208.

Piper blancoi MERR. in Philip. Journ. Sci. 1 (1906) Suppl. 40.

Piper puberulinodum C. DC. in Leafl. Philip. Bot. 3 (1910) 773, Philip. Journ. Sci. 5 (1910) Bot. 429, Candollea 1 (1923) 187; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

Piper carnistylum C. DC. in Leafl. Philip. Bot. 3 (1910) 774, Philip. Journ. Sci. 5 (1910) Bot. 432, Candollea 1 (1923) 240; MERR., Enum. Philip. Fl. Pl. 2 (1923) 6.

A diœcious vine; the branches glabrous, terete, 2.5 to 5 mm in diameter. Leaves chartaceous to subcoriaceous, upper leaves

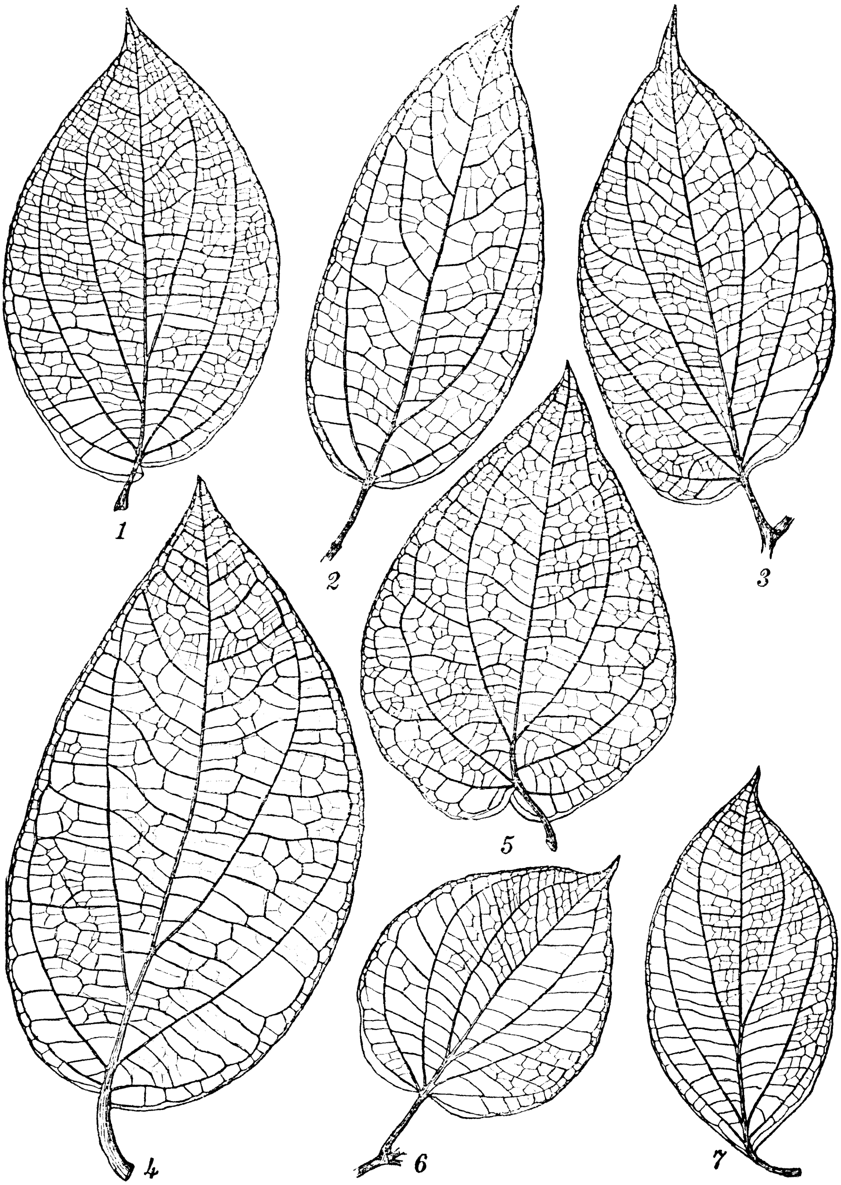


FIG. 41. Leaves of: *3–5, 7, Piper betle* Linn.; *1*, var. *densum* (Blume) C. DC.; *2*, var. *macgregorii* (C. DC.) comb. nov.; *6*, var. *fenixii* (C. DC.) comb. nov. All × 0.5.

usually oblong-elliptic, oblong-ovate, or ovate, the lower ones usually ovate to rounded-ovate, 6 to 17.5 cm long, 3.5 to 10 cm wide, in the lower leaves up to 12 cm wide, base equilaterally to inequilaterally obtuse to rounded, rarely acute or subacute, in the lower leaves usually equilaterally subcordate or cordate, 7-plinerved, apex acutely acuminate or narrowed acute, glabrous

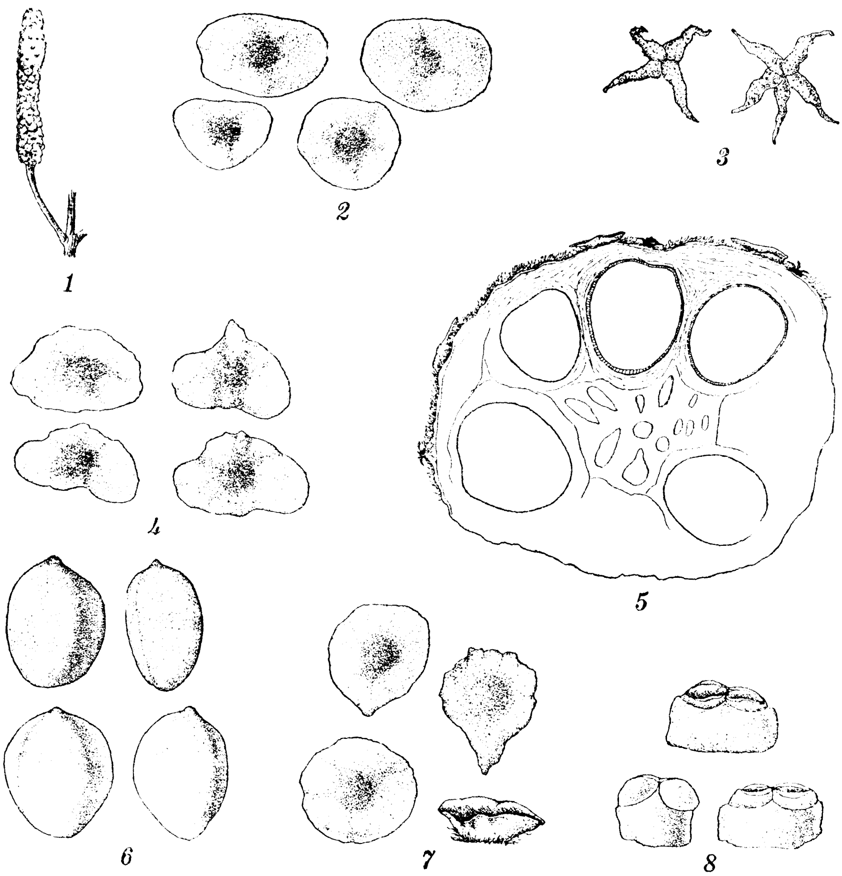


FIG. 42. *Piper betle* Linn.: *1*, mature pistillate spike, × 0.5; *2*, top view of pistillate bracts, × 10; *3*, stigmas, × 10; *4*, top view of pistillate bracts (var. *densum*), × 10; *5*, transverse section of a mature pistillate spike, × 7.5; *6*, seeds, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, × 10.

on both surfaces, reticulations somewhat obscure in the young leaves, prominent in the mature beneath; petioles glabrous, 10 to 20 mm long, in the lower leaves up to 40 mm long. Pistillate spikes oblong to elongated oblong, 3 to 8 cm long, 0.6 to 1 cm in diameter; the peduncles glabrous, 1.5 to 3.5 cm long; rachis hirsute to densely hirsute; bracts sessile, peltate, disk glabrous,

transversely oblong to suborbicular, about 1 mm wide; fruits coalescing, fully embedded in the pulp and concrescent with the rachis; seeds oblong to globose-obovoid, 2.25 to 2.6 mm long, about 2 mm in diameter, glabrous; stigmas 4 to 6, rarely 3, lanceolate, acute, up to 0.6 mm long, sessile, apical. Staminate spikes subpendulous, slender, 7 to 13.5 cm long, 2 to 3.5 mm in diameter; the peduncles glabrous, 1.5 to 3.8 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous, obovate to orbicular, 1 to 1.3 mm wide; stamens 2, pedicellate, 0.75 to 1 mm long, anthers reniform, tetralocular, 2-valved, dehiscence apical, 0.6 to 1 mm wide, filaments oblong, stout, as long as the anthers or slightly longer.

LUZON, Isabela Province, Maluno, *Warburg 11928:* Nueva Viscaya Province, Dupax, *Bur. Sci. 11221, 14179, 11409, 11441, 11500, 14172 McGregor:* Lepanto Subprovince, Cervantes, *Vanoverbergh 2123;* without definite locality, *Bona 400:* Pangasinan Province, San Quintin, *Antonio 5607,* some of the lower leaves of this specimen may be mistaken for those of *Piper longum* Linn.: Bulacan Province, Norzagaray, *Bur. Sci. 13031 Ramos;* Angat, *Bur. Sci. 21749 Ramos;* Galas, *Bur. Sci. 24733 Leuterio:* Bataan Province, Lamao River, Mount Mariveles, *Williams 511, Whitford 188, Merrill 2526, 3781;* Bamban, *For. Bur. 23212 Alhambra and Canlas;* Dinalupihan, *Merrill 1561:* Rizal Province, Mendez, *Bur. Sci. 1314 Mangubat;* Morong, *Bur. Sci. 1368 Ramos;* Antipolo, *Bur. Sci. 13524 Ramos, Merr. Sp. Blancoanae 788, 835:* Cavite Province, Alfonso, *Bur. Sci. 22549 Ramos and Deroy:* Laguna Province, San Antonio, *Bur. Sci. 16639, 20528 Ramos;* Paete, *Bur. Sci. 27864, 27886 McGregor;* Los Baños, *Bur. Sci. 9689, 17289 Robinson, Holman 190, Baker 972, 851, Asuncion 5390, Elmer 17579, 18230;* Mount San Cristobal, *Miras 6418;* Calauan, *Cuming 485* (type collection of *Piper philippinense* C. DC.) : Tayabas Province, Lucban, *Elmer 8094* (type collection of *Piper carnistylum* C. DC.) ; Guinayangan, *Bur. Sci. 20867 Escritor;* Mount Binuang, *Bur. Sci. 28837 Ramos and Edaño;* Umiray, *Bur. Sci. 28970 Ramos and Edaño;* Casiguran, *Bur. Sci. 45356 Ramos and Edaño:* Camarines Sur Province, Sagnay, *Bur. Sci. 22134 Ramos;* Camaligan, *Piper 94.* ALABAT, *Bur. Sci. 48244 Ramos and Edaño.* MINDORO, Pinamalayan, *Bur. Sci. 40905 Ramos.* LEYTE, Dagami, *Wenzel 23, 486;* Tigbao, *Wenzel 1544.* BOHOL, Sevilla, *Bur. Sci. 42785 Ramos.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34373 Ramos and*

Pascasio; Placer, *Wenzel 2655:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13554* : Davao Province, Todaya, Mount Apo, *Elmer 11972* (type collection of *Piper puberulinodum* C. DC.) ; Mati, *Bur. Sci. 49239 Ramos and Edaño.* JOLO, *Warburg 14844* (type of *Piper bathycarpum* C. DC.), *Bur. Sci. 44457 Ramos and Edaño.* TAWITAWI, *Bur. Sci. 44114 Ramos and Edaño.* The betle pepper, cultivated throughout the Philippines, also found wild. Malaya to India, planted in other tropical countries.

Local names: Buyo (Bik.) ; buyo-anís (Tag.) ; buyo de anis (Sp.) ; buyo-búyo (Bik.) ; buyog (Mbo.) ; buyok (C.Bis.) ; buyu (Sul.) ; gáoed (Pang.) ; gáued (It.) ; gók (Ibn.) ; íkmo (Tag.) ; íkmong-ilóko (Tag.) ; ítmo (Tag.) ; kanisi (Bis.) ; mamin (Bis., Tag.) ; mamon (Bis.) ; samát (Pamp.) ; samog (Ilk.).

The species is characterized by its unique pistillate spikes and by its upper leaves being usually oblong-elliptic, oblong-ovate, or ovate and the lower ones usually ovate to rounded-ovate. The fruits in these spikes are coalesced, fully embedded in the pulp, and concrescent with the rachis.

Var. **FENIXII** (C. DC.) comb. nov.

Piper fenixii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 425, Candollea 1 (1923) 187; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Leaves rounded-ovate, 7 to 12 cm long, 5.5 to 10 cm wide, shortly and acutely acuminate, base rounded to cordate.

BATAN, Batanes Province, Santo Domingo de Basco, *Bur. Sci. 3652 Fénix* (type collection). LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 32896 Ramos.* Endemic.

Common name: Samoy (Bat.)

This differs from the species only in that the leaves are all rounded-ovate with bases rounded to cordate.

Var. **MACGREGORII** (C. DC.) comb. nov.

Piper macgregorii C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 215, Candollea 1 (1923) 189; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Leaves including the basal ones oblong or oblong-elliptic, 12 to 18 cm long, 4.5 to 8 cm wide, base acute to obtuse, apex obscurely and acutely acuminate; peduncles 3 to 3.5 cm long.

BILIRAN, *Bur. Sci. 18491* (type collection), *18991 McGregor.* In forests, altitude about 300 meters. Endemic.

This differs from the species in that the upper and lower leaves are all oblong or oblong-elliptic.

Var. **DENSUM** (Blume) C. DC.

Piper betle LINN. var. *densum* (Blume) C. DC., Prodr. 16[1] (1869) 360, Candollea 1 (1923) 237.
Piper densum BLUME, in Verh. Bat. Genoots. 11 (1826) 193, *t. 18*.
Chavica densa MIQ., Syst. Pip. (1843) 252, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 37, *t. 32*.
Piper canaliculatum OPIZ in Presl Rel. Haenk. 1 (1828) 156; MIQ., Syst. Pip. (1843) 336.
Piper malarayatensis C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 442, Candollea 1 (1923) 200; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Lamina glabrous above, pubescent on the nerves beneath.

LUZON, without definite locality or province, *Haenke s. n.* (type of *Piper canaliculatum* Opiz in herb. Prague): Batangas Province, Mount Malarayat, *Copeland s. n.* (type of *Piper malarayatensis* C. DC. in herb. Manila). JOLO, *Bur. Sci. 44422 Ramos and Edaño.* India to Java and Borneo.

The variety is identical with the species in all respects except that the leaves are pubescent on the nerves beneath.

38. **PIPER LANGLASSEI** C. DC. Text fig. 43.

Piper langlassei C. DC. in Ann. Conserv. Jard. Bot. Genéve 2 (1898) 273, Philip. Journ. Sci. 5 (1910) Bot. 433, Candollea 1 (1923) 182, 194; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

A diœcious vine; the branches glabrous, terete, 1.5 to 2.5 mm in diameter, divaricate, somewhat fragile. Leaves chartaceous, subovate-elliptic, 5 to 7 cm long, 2 to 3.8 cm wide, base inequilaterally acute, 7-plinerved, apex acute, glabrous on both surfaces, pale when dry, reticulations somewhat obscure on both surfaces; petioles glabrous, 2.5 to 4 mm long. Pistillate spikes oblong, elongated, 2.5 to 3 cm long, 7 to 8 mm in diameter; the peduncles glabrous, 1.5 to 1.8 cm long; rachis pilose; bracts sessile, peltate, disk glabrous, subelliptic, about 0.75 mm long, 0.5 mm wide; fruits coalescing, fully embedded in the pulp, oblong-obovoid to subglobose, 2.5 to 3 mm long, 2 to 2.25 mm in diameter; stigmas 3 to 5, sessile, apical, confluent.

LUZON, at the foot of Mount Banahao, *Langlasse 97* (type in herb. de Candolle; isotypes in herb. Paris Museum and in herb. Manila).

This species has the vegetative appearance of *Piper varibracteum* C. DC., differing conspicuously in its pistillate spikes, in which the fruits are coalesced and fully embedded in the pulp. In this respect it is allied to *Piper betle* Linn., differing from this in its smaller, subovate-elliptic leaves with inequilaterally acute bases and confluent stigmas.

FIG. 43. *Piper langlassei* C. DC.; *1*, fruiting branch, × 0.5; *2*, longitudinal section of a portion of the pistillate spike, × 7; *3*, bracts, × 7; *4*, stigmas, × 7.

39. PIPER ASTEROSTIGMUM sp. nov. Text fig. 44; Plate 8.

Frutex dioicus, scandens, ramis glabris, subteretibus, 3 ad 6 mm diametro; foliis oblongo-ovatis, 8 ad 12.5 cm longis, 4 ad 6 cm latis, basi subinaequilateralibus, obtusis, 7-plinerviis, apice acute acuminatis, coriaceis, utrinque glabris; spicis ♀

oblongo-ovoideis ad oblongo-obovoideis, 3.5 ad 3.8 cm longis, 1.5 ad 1.7 cm diametro; pedunculis 4 ad 6.5 cm longis; rachis dense pubescentibus; bracteis sessilibus, peltatis, peltis carnosis, glabris, triangularis, circiter 1.5 mm latis; baccis profunde immersis; seminibus glabris, laevis, oblongis ad oblongo-ovoideis, 3 ad 3.25 mm longis; stigmatibus 4 ad 6, plerumque 5, stellatis.

A diœcious vine; the branches glabrous, subterete, smooth, 3 to 6 mm in diameter. Leaves firmly coriaceous, oblong-ovate, 8 to 12.5 cm long, 4 to 6 cm wide, base subinequilaterally obtuse, 7-plinerved, apex acutely acuminate, glabrous on both surfaces, shining above, pale, the nerves conspicuously sunken above, reticulations somewhat obscure; petioles glabrous, 1.5 to 2.5 cm long. Pistillate spikes oblong-ovoid to oblong-obovoid, 3.5

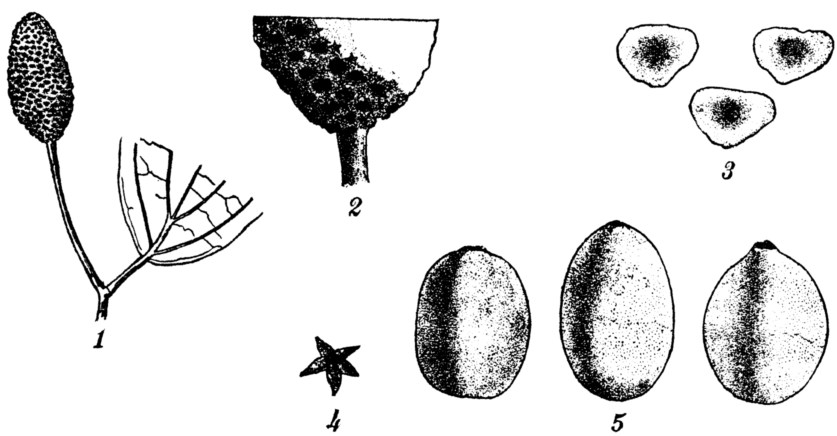


FIG. 44. *Piper asterostigmum* sp. nov.; *1*, mature pistillate spike and base of a leaf, × 0.5; *2*, portion of the mature pistillate spike, enlarged; *3*, top view of bracts, × 7.5; *4*, stigmas, × 7.5; *5*, seeds, × 7.5.

to 3.8 cm long, 1.5 to 1.7 cm in diameter; the peduncles glabrous, 4 to 6.5 cm long; rachis densely pubescent with short, soft hairs; bracts sessile, peltate, disk glabrous, fleshy, triangular, 1 to 1.25 mm long, about 1.5 mm wide; fruits fully embedded in the pulp; seeds glabrous, smooth, oblong to oblong-ovoid, 3 to 3.25 mm long, 2 to 2.1 mm in diameter; stigmas 4 to 6, usually 5, sessile, conspicuously stellate, up to 0.75 mm in length.

MINDANAO, Surigao Province, Placer, *Wenzel 3121* (type in herb. University of California; isotype in herb. Manila), September 5, 1927, in forests, altitude about 150 meters.

A species closely allied to *Piper betle* Linn., differing in its broader spikes, longer peduncles, conspicuously white and stel-

late stigmas, and its firmly coriaceous leaves with sunken nerves above.

40. PIPER FIRMOLIMBUM C. DC. Text figs. 45 and 46; Plate 19.

Piper firmolimbum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 435, Candollea 1 (1923) 188; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

A diœcious vine; the branchlets sometimes hirsute, the branches glabrous, terete, 1.5 to 3 mm in diameter. Leaves firm, chartaceous to subcoriaceous, elliptic-lanceolate to oblong-

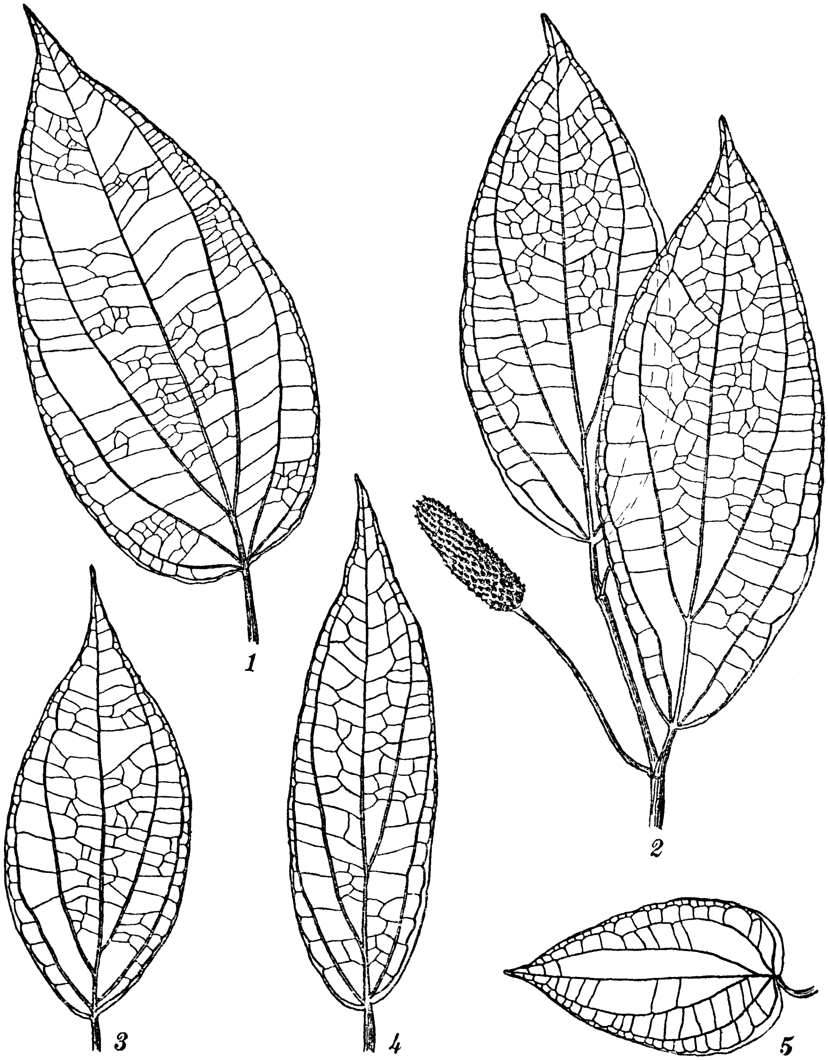


FIG. 45. *Piper firmolimbum* C. DC.; *1, 3–4*, leaves, × 0.5; *2*, fruiting branch with mature pistillate spike, × 0.5; *5*, var. *parvilimbum* var. nov., leaf, × 0.5.

ovate, 11 to 16.5 cm long, 4 to 5.5 cm wide, in the lower leaves up to 10 cm wide, base equilaterally to subequilaterally acute to subrounded, 7-plinerved, apex shortly and acutely acuminate to acutely acuminate, glabrous and shining above, glabrous to sparsely hirsute on the nerves beneath, nerves sunken above, reticulations more or less distinct on both surfaces; petioles glabrous to hirsute, 10 to 22 mm long. Pistillate spikes oblong, 2.2 to 5.3 cm long, 9 to 10 mm in diameter; the peduncles gla-

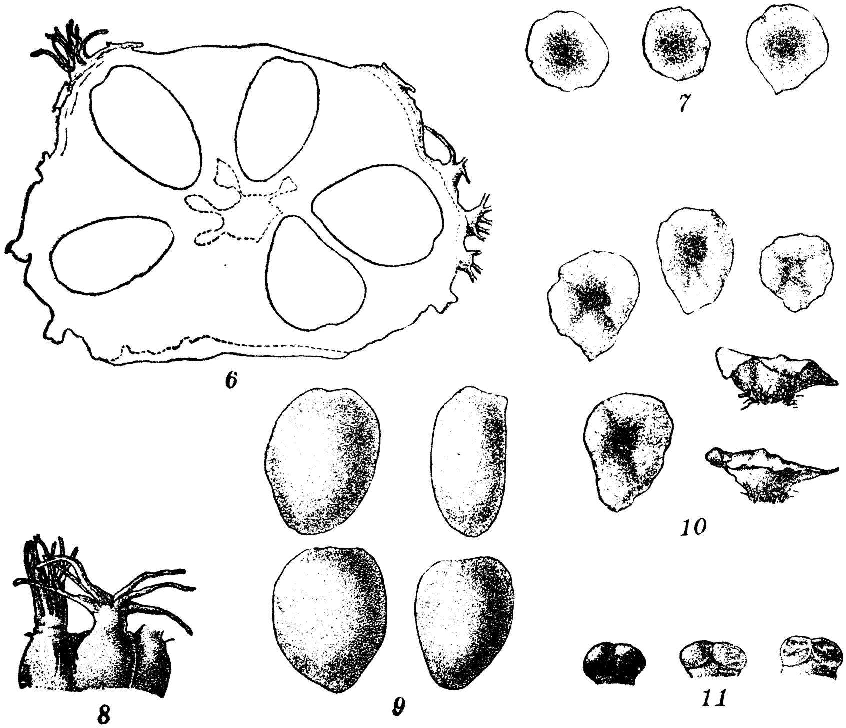


FIG. 46. *Piper firmolimbum* C. DC.; *6*, transverse section of a mature pistillate spike, enlarged; *7*, top view of pistillate bracts, × 10; *8*, young fruits showing stigmas, × 10; *9*, seeds, × 7.5; *10*, top and side views of staminate bracts, × 10; *11*, stamens, × 10.

brous, 3 to 5.8 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous, rounded-obovate to orbicular, 0.75 to 1 mm wide; fruits concrescent; seeds oblong to oblong-obovoid, apex usually truncate, 2.5 to 2.75 mm long, 1.25 to 2 mm in diameter; stigmas usually 6 or 8, rarely 4 or 5, elongated, 1 to 1.25 mm long, erect or curved, slender, puberulent. Staminate spikes pendulous, 6 to 11 cm long, about 2 mm in diameter; the peduncles glabrous, 2 to 3 cm long; rachis hirsute; bracts sessile, subimbricate, peltate, disk glabrous, fleshy, rounded-obovate to oblong-obovate, 1 to 1.5 mm long, about 1 mm wide; stamens 2, subsessile, anthers

reniform, 2-valved, dehiscence apical, filaments stout, very much shorter than the anthers.

LUZON, Laguna Province, Los Baños, Mount Maquiling, *Elmer 17985, 17706, 18190.* ALABAT, *Bur. Sci. 47974, 48198 Ramos and Edaño.* LEYTE, Tacloban, Tigbao, *Wenzel 1622.* MINDANAO, Lanao Province, Lake Lanao, Camp Keithley, *Clemens s. n.* (type in herb. Manila). In forests at low and medium altitudes. Endemic.

A species doubtless closely related to *Piper longistigmum* C. DC., but differing conspicuously in its vegetative characters, as for example the sunken nerves on the surface of the lamina.

Var. PARVILIMBUM var. nov.

Foliis ovatis, 6 ad 8 cm longis, 3 ad 4.5 cm latis.

Leaves ovate, 6 to 8 cm long, 3 to 4.5 cm wide, base obtuse to rounded.

LUZON, Sorsogon Province, Irosin, Mount Bulusan, *Elmer 14517* (type in herb. Manila), September, 1916.

This variety differs from the species in the size and form of its leaves.

41. PIPER LONGISTIGMUM C. DC. Text fig. 47.

Piper longistigmum C. DC. in Leafl. Philip. Bot. 3 (1910) 770, Philip. Journ. Sci. 5 (1910) Bot. 428, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

A diœcious vine; the branches terete, glabrous, 1.5 to 4 mm in diameter. Leaves chartaceous, brown, lanceolate, 10.5 to 18.5 cm long, 3 to 5 cm wide, base equilaterally subacute to acute, 7-plinerved, apex narrowed, acute, glabrous on both surfaces, reticulations prominent on both surfaces; petioles glabrous, 10 to 20 mm long, in the lower leaves up to 30 mm long. Pistillate spikes oblong, 3 to 3.7 cm long, about 8 mm in diameter; the peduncles glabrous, 4.5 to 8 cm long; rachis glabrous; bracts sessile, peltate, disk suborbicular to orbicular, 1 to 1.25 mm wide; fruits concrescent, crowded; seeds oblong to oblong-obovoid, about 3 mm long, 1.75 to 2 mm in diameter; stigmas elongated, 4 or 5, rarely 3 or 6, erect to curved at the apex, slender, puberulent, 0.5 to 1.5 mm long.

LUZON, Tayabas Province, Lucban, *Elmer 7578* (type collection). CATANDUANES, Santo Domingo River, *Bur. Sci. 30493 Ramos.* In forests at low altitudes. Endemic.

A distinct species probably allied to *Piper betle* Linn., strongly characterized by its long slender stigmas which measure up to 1.5 mm in length and its lanceolate leaves.

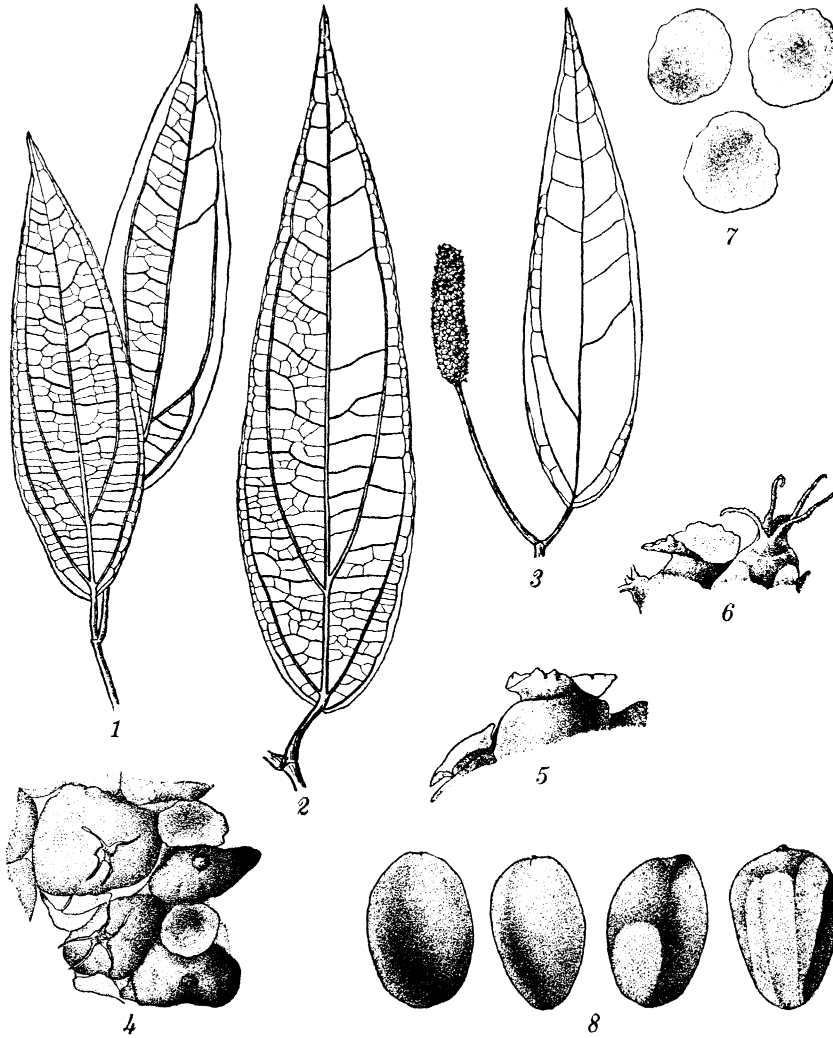


FIG. 47. *Piper longistigmum* C. DC.; *1–2*, leaves, × 0.5; *3*, leaf and a mature pistillate spike, × 0.5; *4*, portion of the top view of a mature pistillate spike, × 7.5; *5*, side view of pistillate bracts, × 10; *6*, side view of a pistillate bract and a young fruit, × 10; *7*, top view of pistillate bracts, × 10; *8*, seeds, × 7.5.

42. PIPER BAGUIONUM C. DC. Text fig. 48; Plate 17, fig. 10.

Piper baguionum C. DC. in Leafl. Philip. Bot. 3 (1910) 775, Philip. Journ. Sci. 5 (1910) Bot. 434, Candollea 1 (1923) 214; MERR., Enum. Philip. Fl. Pl. 2 (1923) 4.

Piper polycladum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 438, 11 (1916) Bot. 218, Candollea 1 (1923) 192; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

A diœcious vine; the branches glabrous, terete, 1 to 3 mm in diameter. Leaves subcoriaceous, ovate, 5.5 to 10.5 cm long,

2.5 to 5.9 cm wide, base equilaterally to subequilaterally acute to subrounded, 5- to 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations more or less prominent

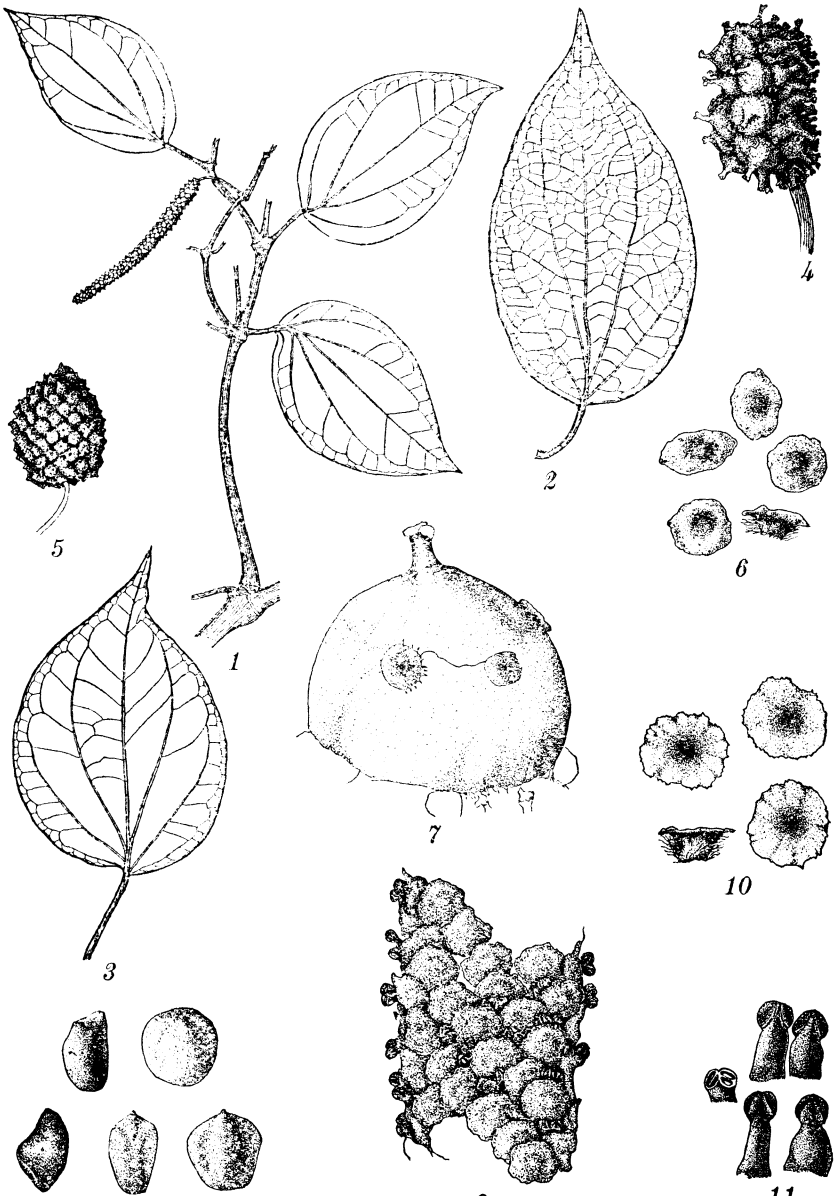


FIG. 48. *Piper baguionum* C. DC.; *1*, fruiting branch, × 0.5; *2–3*, leaves, × 0.5; *4*, young pistillate spike, × 1.8; *5*, mature pistillate spike, × 0.5; *6*, top and side views of pistillate bracts, × 10; *7*, fruit, × 7.5; *8*, seeds, × 2.5; *9*, portion of staminate spike, × 7.5; *10*, side and top views staminate bracts, × 10; *11*, stamens, × 10.

beneath; petioles glabrous, 10 to 25 mm long, in the lower leaves up to 30 mm long. Pistillate spikes oblong-ovoid to broadly ovoid, 2 to 4.5 cm long, 1.6 to 2.5 cm in diameter; the peduncles glabrous, 1.5 to 2.5 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous, elliptic to orbicular, 0.75 to 1 mm wide; fruits concrescent, crowded; seeds globose, umbonate, about 4 mm long, 4 mm wide, 2.5 to 3 mm thick; stigmas 3 or 4, short, erect, oblong, subacute; styles persistent, elongated, slender, about 1 mm long. Staminate spikes pendulous, 3 to 4.5 cm long, 3 to 3.5 mm in diameter; the peduncles glabrous, 12 to 20 mm long; rachis hirsute; bracts subsessile, peltate, disk glabrous, orbicular, about 1 mm wide, margins laciniate, pedicels stout, hirsute; stamens 2, pedicellate, about 1 mm long, anthers subglobose to ovoid, tetralocular, 4-valved, filaments oblong or swollen at the base, twice as long as the anthers, somewhat exerted.

LUZON, Benguet Subprovince, Baguio, *Elmer 8784* (type collection of *Piper baguionum* C. DC.), *5874, Williams 1134* (type of *Piper polycladum* C. DC. in herb. Manila), *Sandkuhl 156, Philip. Pl. 751 Merrill, Bur. Sci. 45086 Ramos and Edaño.* In thickets and forests, altitude about 1,500 meters. Endemic.

A species probably allied to *Piper betle* Linn., but clearly distinct. It is characterized by its rather large and broad, usually ovoid, pistillate spikes, large globose flattened fruits which are united and embedded in the rachis and its laciniate staminate bracts. There are two other species (*Piper angustipeltatum* Merr. and *Piper myrmecophilum* C. DC.) having fruits with long styles, but this is radically different from either in both vegetative and reproductive characters.

43. PIPER ANGUSTIPELTATUM Merr. Text fig. 49.

Piper angustipeltatum MERR. in Philip. Journ. Sci. 17 (1920) 244, Enum. Philip. Fl. Pl. 2 (1923) 3.

A diœcious vine; the branches glabrous, subterete, about 2 mm in diameter. Leaves chartaceous, with minute brown to black dots on both surfaces, oblong, 14 to 16.5 cm long, 5 to 6.5 cm wide, base equilaterally rounded and narrowly peltate, 7-nerved, apex acutely acuminate, glabrous and shining on both surfaces, reticulations somewhat obscure above, more or less prominent beneath; petioles glabrous, 2 to 3 cm long. Pistillate spikes oblong, 2.5 to 3 cm long, about 12 mm in diameter; the peduncles glabrous, about 2 cm long; rachis pilose; bracts sessile, peltate, disk glabrous, suborbicular, 0.75 to 1 mm wide; ovaries

densely crowded; styles greatly elongated, slender, 3 to 4 mm long; stigmas 2, puberulent, recurved.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28846 Ramos and Edaño* (type in herb. Manila), May 19, 1917, in damp forests along rivers at low and medium altitudes. Endemic.

This species is characterized by its narrowly peltate, oblong leaves and by its greatly elongated, slender, crowded styles and conspicuously bilobed stigmas.

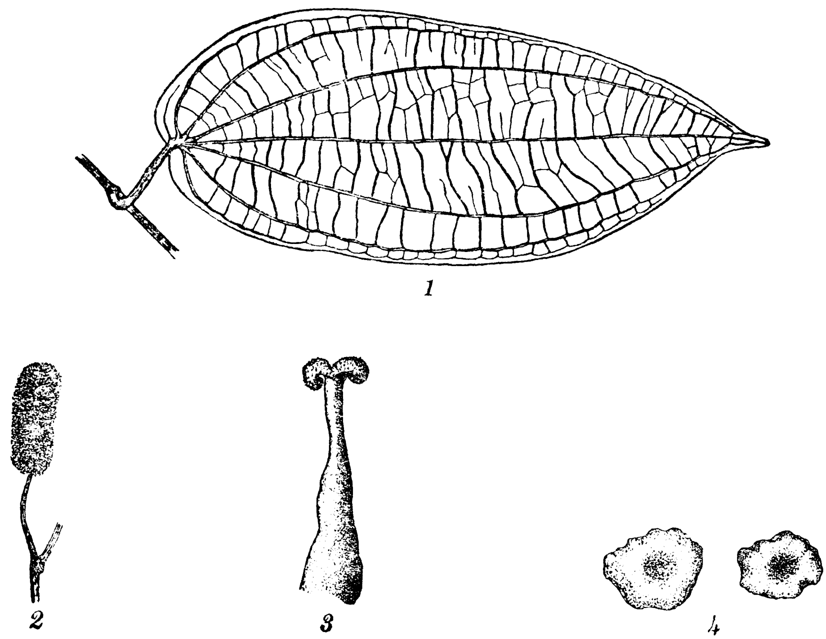


FIG. 49. *Piper angustipeltatum* Merr.; *1*, leaf, × 0.5; *2*, pistillate spike, × 0.5; *3*, pistil with long style and bilobed stigma, × 10; *4*, top view of bracts, × 10.

44. PIPER FRAGILE Benth. Text fig. 50.

Piper fragile BENTH. in Hook. Lond. Journ. Bot. 2 (1843) 234; C. DC., Prodr. 16[1] (1869) 358, Candollea 1 (1923) 182, 184.

Chavica benthamiana MIQ., Syst. Pip. (1843) 233.

Piper fragile Benth. var. *multinerve* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 421, 11 (1916) Bot. 208, Candollea 1 (1923) 182; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

A diœcious vine; the branches glabrous, subterete, fragile at the nodes, 1.5 to 3 mm in diameter. Leaves chartaceous, elliptic-ovate to rounded-ovate, 4 to 7.5 cm long, 3 to 7 cm wide, base equilaterally acute, in the lower leaves rounded, subpeltate to

peltate, 5-nerved, apex shortly and acutely acuminate to acute, glabrous on both surfaces, reticulations somewhat obscure above, more or less prominent beneath; petioles glabrous, longer in the female, 1 to 2 cm long, in the lower leaves up to 2.5 cm long. Pistillate spikes abbreviated, oblong, 2 to 2.5 cm long, 0.8 to 1 cm in diameter; the peduncles glabrous, 1 to 1.5 cm long; rachis slightly hirsute; bracts sessile, peltate, disk glabrous, suborbi-

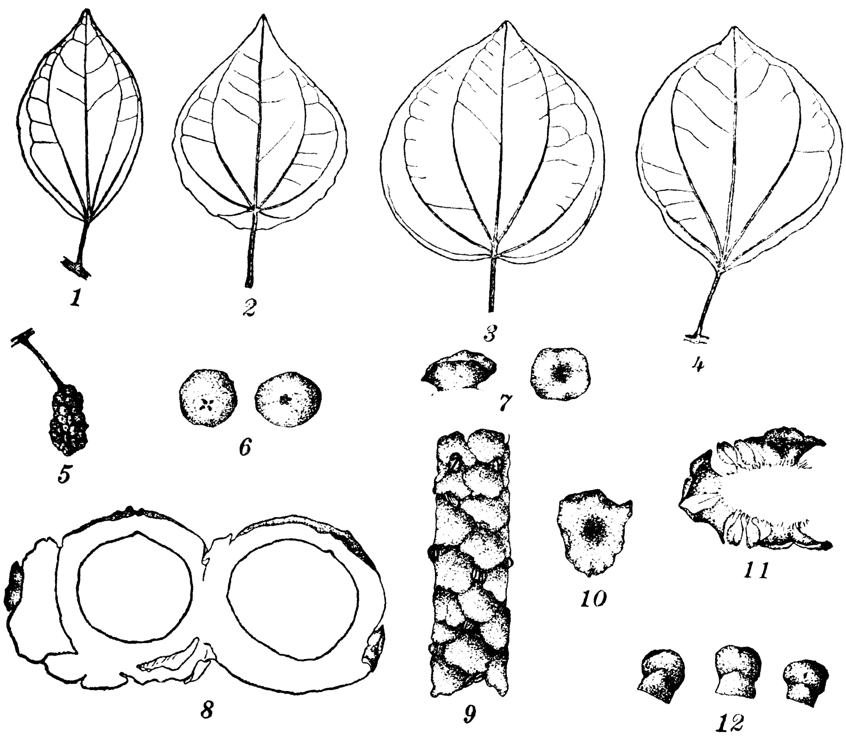


FIG. 50. *Piper fragile* Benth.: *1–4*, leaves, × 0.5; *5*, mature pistillate spike, × 0.5; *6*, top view of fruits, × 2.5; *7*, side and top views of pistillate bracts, × 10; *8*, portion of the transverse section of a pistillate spike, × 7.5; *9*, portion of a staminate spike, × 10; *10*, top view of a staminate bract, × 10; *11*, transverse section of a portion of staminate spike, × 10; *12*, stamens, × 10.

cular, about 0.8 mm wide; fruits free only at the apex, base connate, glabrous, globose, rounded, about 3 mm long, 3 to 3.2 mm in diameter; stigmas 4 or 5, free or more or less confluent, linear, acute, sessile, apical; seeds globose. Staminate spikes slender, 3.5 to 6.5 cm long, 1.5 to 2 mm in diameter; the peduncles glabrous, 1 to 1.7 cm long; rachis hirsute; bracts sessile to subsessile, peltate, disk glabrous, imbricate, orbicular, about 0.75 mm wide; stamens 2, subpedicellate, 0.5 to 0.75 mm long,

anthers ovoid, bilocular, 2-valved, filaments oblong, almost as long as the anthers or shorter.

LUZON, Tayabas Province, Mount Pular, *Bur. Sci. 19426 Ramos:* Camarines Sur Province, Pasacao, *Merrill 3366* (type collection of *Piper fragile* Benth. var. *multinerve* C. DC.). MINDANAO, Davao Province, Mati, *Bur. Sci. 49237, 48959 Ramos and Edaño;* Mount Mayo, *Bur. Sci. 49462 Ramos and Edaño.* BUCAS GRANDE, *Merrill 5271.* On rocks near the sea, in thickets and forests at low and medium altitudes. The species was originally described from New Guinea, but has recently been found on Banguey Island, British North Borneo.

Local name: Litlít-aníto (Tag.).

Bur. Sci. 40791 Ramos collected from Mount Angilog, Rizal Province, at an altitude of about 1,000 meters, resembles *Piper fragile* Benth. in most of its superficial characters, but differs in leaf apex, reticulations, and the subpeltate to peltate leaves; but due to imperfect material I have decided to postpone further consideration until more mature fruiting specimens are available. I could find no reason for retaining de Candolle's variety as it agrees in all respects with the species.

45. **PIPER SARMENTOSUM** Roxb. Text fig. 51.

Piper sarmentosum ROXB., Fl. Ind. 1 (1820) 162; C. DC., Prodr. 16[1] (1869) 352, Philip. Journ. Sci. 5 (1910) Bot. 424, 11 (1916) Bot. 218, Candollea 1 (1923) 187, 200; MERR., Interp. Rump. Herb. Amb. (1917) 185, Enum. Philip. Fl. Pl. 2 (1923) 15.

Chavica sarmentosa MIQ., Syst. Pip. (1843) 242.

Sirium terrestre RUMPH., Herb. Amb. 5: 344, *t. 119, f. 1.*

Piper zollingerianum C. DC., Prodr. 16[1] (1869) 351, Candollea 1 (1923) 286.

Piper zamboangae C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 424, Candollea 1 (1923) 185; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper siassiense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 443, Candollea 1 (1923) 205; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

Piper allenii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 441, Candollea 1 (1923) 203; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

An erect suffrutescent undershrub, never over 1 meter high, branching at the top, the young branches minutely puberulent, older ones glabrous, terete, 1.5 to 2.5 mm in diameter. Leaves chartaceous, the upper ones elliptic-ovate, oblong-ovate or ovate, the lower ones broadly ovate, 4.5 to 13.5 cm long, 2 to 10.5 cm wide, base equilaterally to subequilaterally subacute to rounded, in the lower leaves equilaterally subcordate to cordate, 7-plinerved, apex acutely acuminate, glabrous above, minutely puberulent on the nerves beneath, reticulations somewhat obscure

above, prominent beneath; petioles minutely puberulent, 2 to 18 mm long, in the lower leaves usually longer, 20 to 50 mm in length. Pistillate spikes abbreviated, oblong, 11 to 17 mm long, 5 to 8 mm in diameter; the peduncles minutely puberulent, 12 to 19 mm long; rachis glabrous; bracts subsessile, peltate, becoming compressed at maturity of the fruits, disk glabrous, suborbicular when spread, 1 to 1.25 mm wide; fruits free, base embedded in and concrescent with the rachis, tetragonous, gla-

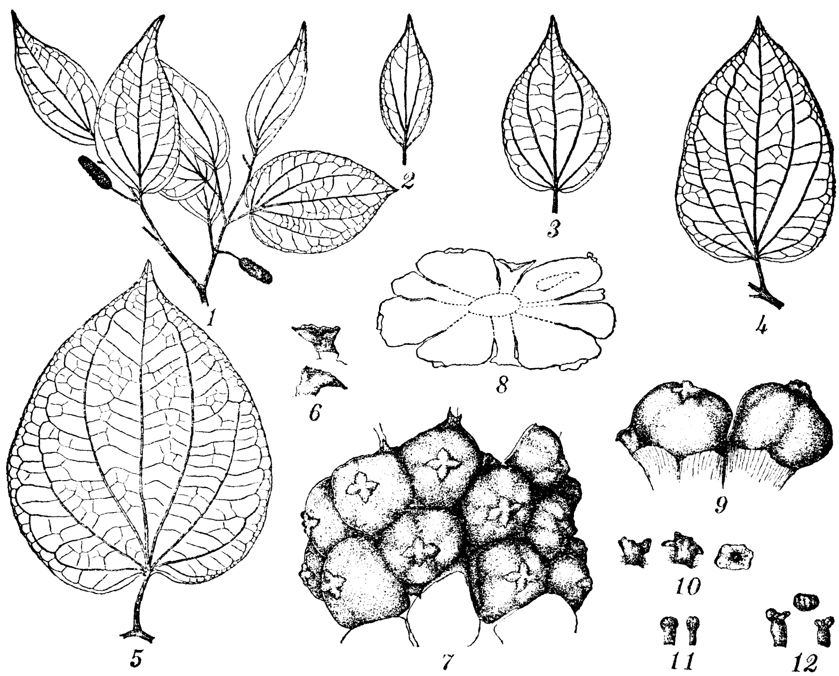


FIG. 51. *Piper sarmentosum* Roxb.; *1*, fruiting branch, × 0.3; *2–4*, upper leaves, × 0.3; *5*, lower leaf, × 0.3; *6*, side view of pistillate bracts, × 5; *7*, top view of portion of mature pistillate spike, × 5; *8*, transverse section of mature pistillate spike, × 5; *9*, side view of two fruits, × 5; *10*, side and top views of staminate bracts, × 6.5; *11*, stamens before dehiscence, × 6.5; *12*, stamens after dehiscence, × 6.5.

brous, obovoid, 2 to 2.5 mm long, about 2 mm in diameter; stigmas usually 4, rarely 3 or 5, oblong-ovoid, sessile, apical, puberulent. Staminate spikes slender, 8 to 11 mm long, 1.5 to 2 mm in diameter; the peduncles minutely puberulent, 5 to 7 mm long; rachis hirtellous; bracts subsessile, peltate, disk glabrous, membranaceous, transverselly elliptic, 0.5 to 0.6 mm wide; pedicels stout, hirtellous; stamens 2, pedicellate, 0.5 to 0.75 mm long, anthers small, subglobose, bilocular, 2-valved, filaments about twice as long as the anthers, not exerted.

SAMAR, Borongan, *Merrill 11598.* NEGROS, Occidental Negros Province, Kabancalan, *Merrill 6729.* PALAWAN, Sir. J. Brooke Point, *Elmer 12587;* Lake Manguao, *Merrill 9480;* Puerto Princesa, *Bur. Sci. 45908 McGregor.* MINDANAO, Surigao Province, Surigao, *Allen 152* (type of *Piper allenii* C. DC. in herb. Manila), *Bur. Sci. 34429 Ramos and Pascasio:* Zamboanga Province, without definite locality, *Hallier s. n.* (type of *Piper zamboangae* C. DC. in herb. Manila). CAMIGUIN DE MISAMIS, Mambajao, *Elmer 14245.* SIASI, *Merrill 5311* (type collection of *Piper siassiense* C. DC.). In thickets, coco grooves, etc., at low altitudes. India to southern China, southward to the Moluccas.

Local name: Juan (Mbo.).

A species somewhat allied to *Piper betle* Linn., differing in its free fruits and habit of growth. The plant is usually an undershrub, and never attains a height of over 1 meter.

46. **PIPER SIBULANUM C. DC.** Text fig. 52; Plate 9.

Piper sibulanum C. DC. in Perk. Frag. Fl. Philip. (1905) 158, Philip. Journ. Sci. 5 (1910) Bot. 442, Candollea 1 (1923) 187; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

Piper oophyllum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 430, Candollea 1 (1923) 189; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper oophyllum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 430, Candollea 1 (1923) 186; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper sarmentosum Roxb. forma *b* C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 218.

A triœcious (female, male, and hermaphrodite) vine; the young branches minutely puberulent, the older ones glabrous, terete, 1.5 to 3 mm in diameter. Leaves chartaceous, oblong-ovate to rounded-ovate, 8.5 to 16 cm long, 4 to 11.5 cm wide, base equilaterally to subequilaterally subobtuse to rounded, 7- to 9-plinerved, apex shortly acuminate, acumen subobtuse to obtuse, glabrous above, minutely puberulent on the nerves beneath, reticulations prominent on both surfaces; petioles minutely puberulent, 10 to 20 mm long, in the lower leaves up to 30 mm long. Pistillate spikes oblong, 2.5 to 3.5 cm long, 5 to 9 mm in diameter; the peduncles minutely puberulent, 3 to 8 mm long; rachis sparsely pilose; bracts sessile, peltate, disk glabrous, orbicular, 0.75 to 1 mm wide; fruits not free, partly embedded in and concrescent with the rachis, glabrous, globose, about 2.5 mm long, 2 mm in diameter; stigmas 3 or 4, oblong-ovoid, sessile, apical; seeds glabrous, globose, about 2 mm long. Staminate spikes 4.5 to 7 cm long, about 2 mm in diameter; the peduncles minutely puberulent, 7 to 8 mm long; rachis pilose; bracts sessile, peltate, disk orbicular, about 0.75 mm wide; stamens 2, sub-

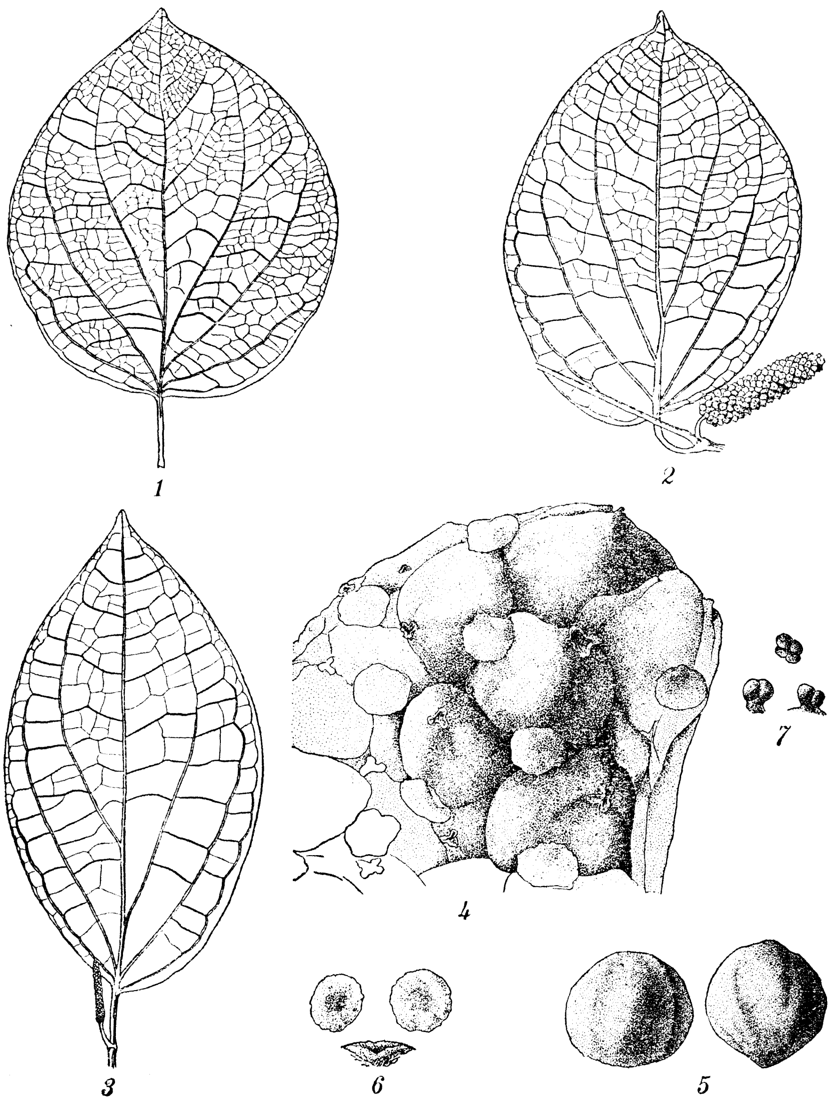


FIG. 52. *Piper sibulanum* C. DC.; *1*, leaf, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, leaf and staminate spike, × 0.5; *4*, top view of a portion of a mature pistillate spike, × 7.5; *5*, seeds, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

sessile, anthers small, subglobose, tetralocular, 2-valved. Hermaphroditic spikes oblong, 2 to 3 cm long, about 5 mm in diameter; the peduncles minutely puberulent, 5 to 6 mm long, rachis sparsely pilose; bracts and fruits like those of the female spikes, except the fruits are slightly smaller; the stamens and staminate bracts like those of the staminate spikes.

MINDANAO, Bukidnon Province, Tangkulan, *Bur. Sci. 26095 Fénix:* Davao Province, Sibulan, *Warburg 14742* (type of *Piper sibulanum* C. DC. in herb. Berlin); Davao, *Copeland 333* (type collection of *Piper oophyllum* C. DC.), *320;* Mati, *Piper 449* (type collection of *Piper sarmentosum* Roxb. forma *b* C. DC.), *431, Bur. Sci. 49062, 49184, 49599 Ramos and Edaño;* Santa Cruz, *Williams 2750* (type of *Piper williamsii* C. DC. in herb. Manila), *De Vore and Hoover 233:* Zamboanga Province, Malangas, *Bur. Sci. 36987 Ramos and Edaño.* In forests at low altitudes. Endemic.

Local name: Lauiñgan (Sub.).

A species with vegetative characters approaching *Piper sarmentosum* Roxb., differing in its habit and in its united, not free fruits. This species bears much resemblance to *Piper betle* Linn., but differs radically from the latter species, in having hermaphroditic spikes and minutely puberulent branchlets, petioles and peduncles and nerves beneath of the lamina.

47. PIPER PARONG sp. nov. Text fig. 53; Plate 10.

Frutex scandens, hermaphroditus; ramulis junioribus minute hirtellis, vetustioribus glabris; foliis chartaceis, elliptico-ovatis, 12.5 ad 16 cm longis, 6.5 ad 9.5 cm latis, basi aequilateralibus ad subaequilateralibus cuneatis, 7-plinerviis, apice subacute acuminatis, supra glabris, subtus hirtellis; spicis ⚥ elongato-oblongis, recurvatis, 8.5 ad 9 cm longis, 7 ad 8 mm diametro; rachis sparse hirtellis; bracteis sessilibus, peltatis, peltis transverse subrotundatis, supra marginibusque glabris; fructibus haud liberis, partem immersis, oblongo-ovoideis, 2.25 ad 3.25 mm longis, 2 ad 2.25 mm latis; stigmatibus 3 vel 4, ovoideis, acutis; staminibus 2, sessilibus ad subsessilibus, antheris oblongis, 2-valvatis.

A hermaphroditic vine; young branches minutely hirtellous, older ones glabrous, terete, 1.5 to 3.5 mm in diameter. Leaves chartaceous, elliptic-ovate, 12.5 to 16 cm long, 6.5 to 9.5 cm wide, base equilaterally to subequilaterally cuneate, 7-plinerved, apex subacutely acuminate, glabrous above, hirtellous on the nerves beneath, reticulations more or less prominent on both surfaces; petioles minutely puberulent, long, 16 to 25 mm long. Hermaphroditic spikes recurved, elongated-oblong, 8.5 to 9 cm long, 7 to 8 mm in diameter; the peduncles glabrous to very sparingly pubescent, 8 to 10 mm long; rachis sparsely hirtellous; bracts sessile, peltate, disk glabrous, transversely subrounded, 0.6 to 0.75 mm wide; fruits not free, partly embedded in and concrescent with the rachis, glabrous, oblong-ovoid, subacute,

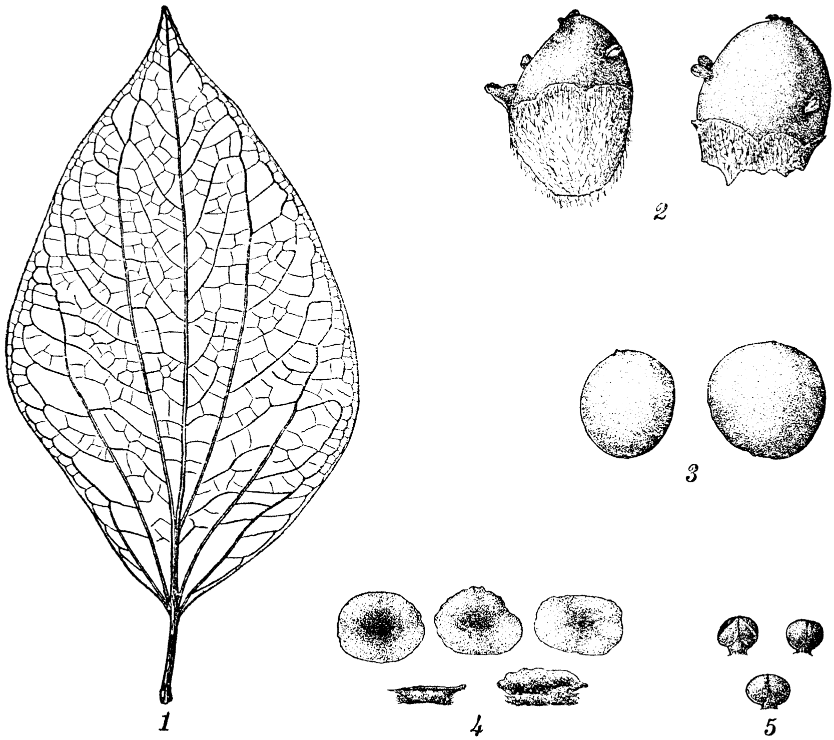


FIG. 53. *Piper parong* sp. nov.; *1*, leaf, × 0.5; *2*, fruits, × 7.5; *3*, seeds, × 7.5; *4*, top and side views of bracts, × 10; *5*, stamens, × 10.

2.25 to 3.25 mm long, 2 to 2.25 mm in diameter; stigmas 3 or 4, ovoid, acute, sessile, apical; seeds subglobose, about 2 mm long, 1.75 mm in diameter; stamens 2, scattered on the spike, sessile to subsessile, anthers small, subglobose, 2-valved.

SAMAR, Palapag, Catubig, *Bur. Sci. 24465* (type in herb. Manila), March 11, 1916, *24486 Ramos,* Feb. 20, 1916. In thickets and forests along streams at low altitudes.

Common name: Párong (Bis.).

This species is close to *Piper sibulanum* C. DC., but differs from it in its longer, recurved hermaphroditic spikes, and its elliptic-ovate leaves with cuneate bases.

48. PIPER RETROFRACTUM Vahl. Text figs. 54 and 55.

Piper retrofractum VAHL, Enum. 1 (1804) 314; USTERI, Beitr. Ken. Philip. Veg. (1905) 125; C. DC. Prodr. 16[1] (1869) 378, Perk. Frag. Fl. Philip. (1905) 157 (incl. var. *latifolium* C. DC.), Philip. Journ. Sci. 5 (1910) Bot. 439, 11 (1916) Bot. 218, Leafl. Philip. Bot. 3 (1910) 776, Candollea 1 (1923) 208–209; MERR., Fl. Manila (1912) 170, Sp. Blancoanae (1918) 118, Enum. Philip. Fl. Pl. 2 (1923) 14.

Chavica ? retrofracta MIQ., Syst. Pip. (1843) 275.

Piper parvifolium BLANCO, Fl. Filip. (1837) 23, ed. 2 (1845) 17, ed. 3, 1 (1877) 32; C. DC., Prodr. 16[1] (1869) 376, Candollea 1 (1923) 230.

Chavica parvifolia HASSK. in Flora 47 (1864) 59.

Piper officinarum C. DC., Prodr. 16[1] (1869) 356, Candollea 1 (1923) 265; F.-VILL., Novis. App. (1880) 175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219.

Chavica officinarum MIQ., Syst. Pip. (1843) 256, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 39, *t. 34*, Fl. Ind. Bat. 1[2] (1858–59) 444.

Piper longum RUMPH., Herb. Amb. 5: 333, *t. 116, f. 1.*

Piper longum e *Philippinis* RUMPH., Herb. Amb. 5: 334.

Pharmacum magnum vulgare RUMPH., Herb. Amb. 5: 42, *t. 26, f. 2?*

Piper longum BLUME in Verh. Bat. Genoots. 11 (1826) 197, *t. 19*, non Linn.

Piper chaba HUNTER in As. Res. 9 (1809) 391; MIQ., Syst. Pip. (1843) 256, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 40; C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 432.

Piper palawanum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 210, Candollea 1 (1923) 266; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branches glabrous, terete, 2 to 3.5 mm in diameter. Leaves pale when dry, chartaceous, oblong, oblong-ovate, or elliptic-lanceolate, 6 to 17.5 cm long, rarely up to 21 cm long, 3.2 to 8.5 cm wide, base subequilaterally to inequilaterally acute to cordulate, penninerved, 7 to 11 nerves on each side of the midrib, apex shortly and acutely acuminate to acute, glabrous on both surfaces, reticulations somewhat obscure above, prominent beneath; petioles glabrous, 5 to 11 mm long, in the lower leaves up to 18 mm long, in the leaves of sterile plants up to 30 mm long. Pistillate spikes oblong, 3.2 to 5.5 cm long, 6.5 to 11 mm in diameter; the peduncles glabrous, 10 to 18 mm long, rarely 30 to 45 mm long; rachis glabrous; bracts sessile, peltate, disk glabrous, usually transversely oblong, sometimes suborbicular, 1 to 1.25 mm wide; fruits more or less united, partly or wholly embedded in and concrescent with the rachis; stigmas 3, short, recurved, ovoid, acute; seeds subglobose to obovoid-globose, 2 to 2.5 mm long. Staminate spikes 3.8 to 8.5 cm long, 2.5 to 4.5 mm in diameter; the peduncles glabrous, 10 to 18 mm long; rachis glabrous; bracts subsessile, peltate, disk glabrous, firm, suborbicular to orbicular; stamens 2 or 3, sessile, anthers broadly oblong, subtetragonous, tetralocular, 4-valved.

BABUYANES ISLANDS, Dalupiri Island, *Bur. Sci. 10651, 10638 McGregor:* Camiguin Island, *Bur. Sci. 4092 Fénix.* LUZON, Ilocos Norte Province, without definite locality, *Cuming 1248;* Burgos, *Bur. Sci. 32932, 32935, 32951 Ramos, 43559 McGregor:* Cagayan Province, Buguey, *Warburg 12125* (type of *Piper retro-*

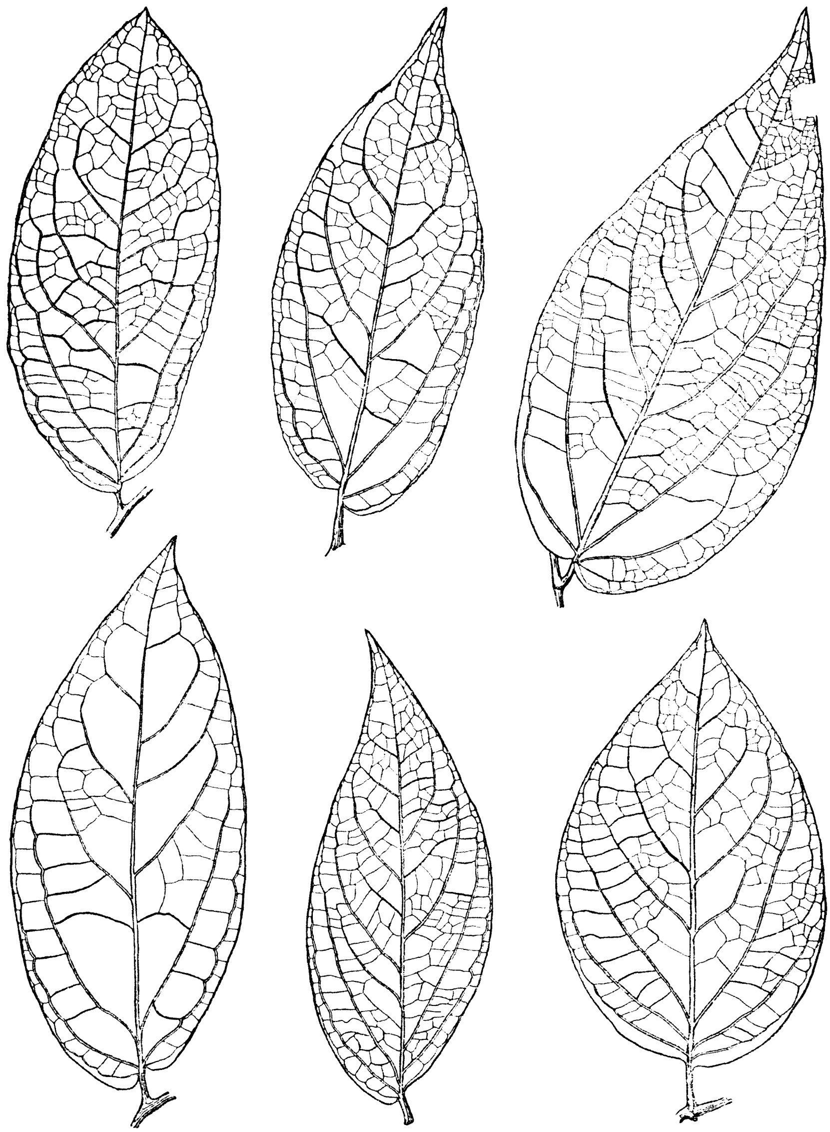


FIG. 54. *Piper retrofractum* Vahl; leaves, × 0.5.

fractum Vahl var. *latifolium* C. DC. in herb. Berlin); Tabuc, *Bolster 157:* Abra Province, Caburao, *For. Bur. 21961 Adduru:* La Union Province, San Fernando, *Lete 69:* Pangasinan Province, Rosales, *Warburg 13318;* Umingan, *Bur. Sci. 17904 Otanes, For. Bur. 22902 Maneja:* Nueva Viscaya Province, Dupax, *Bur. Sci. 8239 Ramos:* Nueva Ecija Province, Cabanatuan, *Bur. Sci.*

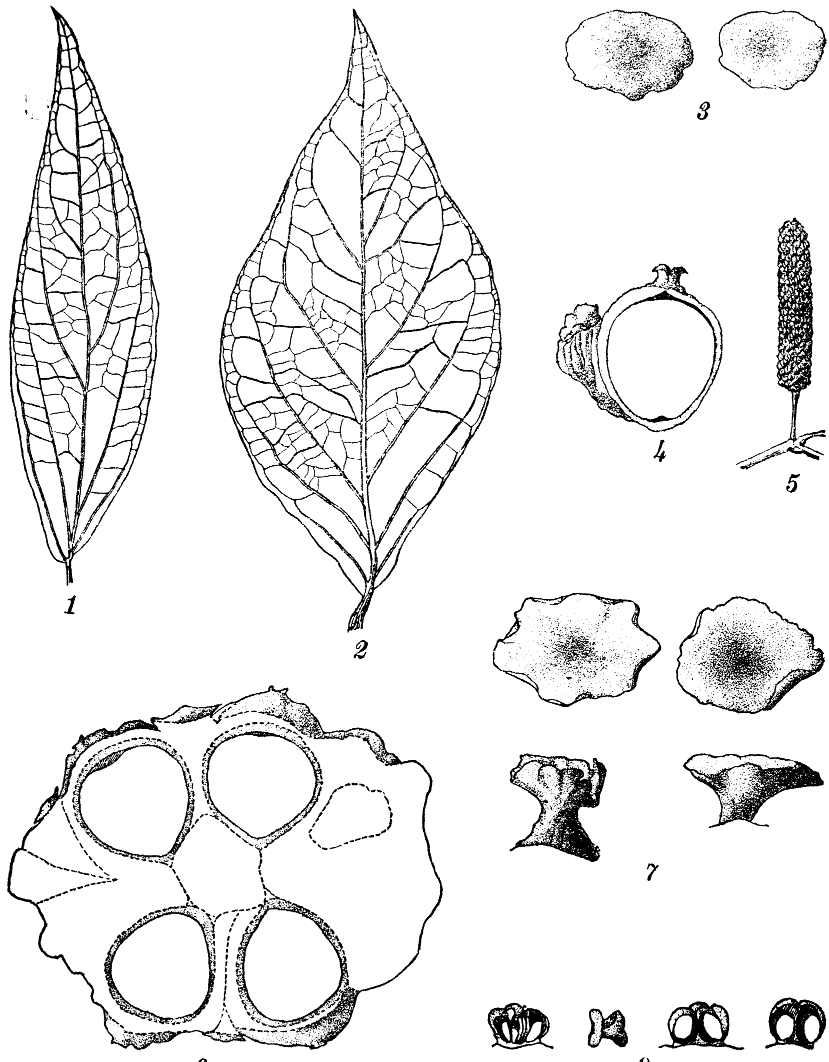


FIG. 55. *Piper retrofractum* Vahl; *1–2*, leaves, × 0.5; *3*, top view of pistillate bracts, × 10; *4*, longitudinal section of a fruit, × 7.5; *5*, mature pistillate spike, × 0.5; *6*, transverse section of a mature pistillate spike, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, 10.

5294 McGregor: Bulacan Province, Angat, *Merr. Sp. Blancoanae 523:* Bataan Province, Mount Mariveles, *Elmer 6862, Williams 302, Merrill 3165, For. Bur. 57 Barnes, 1911 Borden;* Duale, *For. Bur. 20039 Topacio:* Rizal Province, without definite locality, *Vidal 3544;* Masambong, *Philip. Pl. 268 Merrill;* Baras, *Bur. Sci. 11876 Robinson and Ramos;* Jalajala, *Bur. Sci. 11935 Ro-*

binson and Ramos; Malapad na Bato, *Bur. Sci. 12198 Ramos;* Parañaque, *Merrill 7093;* Mount Lumutan, *Bur. Sci. 29771 Ramos and Edaño;* Montalban, *Loher 12733;* Pililla, *For. Bur. 26423 Maneja;* without definite locality, *Philip. Pl. 2020 Ramos, Loher 15043:* Cavite Province, *Bur. Sci. 22530 Ramos and Deroy:* Laguna Province, Galas, *Bur. Sci. 22996, 23128 McGregor;* Pagsanjan, *Langlasse 13;* Los Baños, *Elmer 18088, Gates and Lopez 5636, For. Bur. 20364 Ponce.* MINDORO, Baco, *Merrill 1238, For. Bur. 5512 Merritt;* Puerta Galera, *Merrill 3342;* Pinamalayan, *Bur. Sci. 41042 Ramos.* PANAY, Capiz Province, Mount Timbaban, *Bur. Sci. 42473 Edaño:* Antique Province, Lipata, *Bur. Sci. 32574 McGregor:* Iloilo Province, without definite locality, *Vidal 3527, 3529.* GUIMARAS, *Vidal 3528.* PALAWAN, without definite locality, *Vidal 1672;* Babuyan, *Bur. Sci. 15573 Fénix* (type collection of *Piper palawanum* C. DC.); Ulugan Bay, *Merrill 7216;* Taytay, *Merrill 9254;* Alfonzo, *Bur. Sci. 19341 Weber;* Puerto Princesa, *Bur. Sci. 190 Bermejos;* Iwahig, *Bur. Sci. 851 Foxworthy.* In thickets at low altitudes, usually common. Indo-China and the Malay Peninsula to the Moluccas.

Local names: Amáras (Ilk.); boyo-bóyo (Tagb.); kamára (Ilk.); kayungo (Tag.); litlít (Ilk., Tag.); sabía (Tag.); salimára (Tag.); soag-matsíng (Tag.); súbong-manók (Tag.).

Piper longum as interpreted by Blume is evidently from its description and illustration *Piper retrofractum* Vahl. I agree with Merrill[7] in his interpretation of the Amboina material: "The figure of *Piper longum* Rumph., however, seems to represent Vahl's species, this reduction being in agreement with Miquel and C. de Candolle. I follow Miquel also in reducing here *Pharmacum magnum vulgare* Rumph. who considered that it represented a form near *Chavica officinarum* Miq." I am likewise incorporating here *Piper chaba* Hunter as a synonym on the authority of both Miquel and C. de Candolle.

This species, obviously allied to *Piper philippinum* Miq., differs from it in its glabrous rachis in both male and female spikes, and its larger staminate bracts. The species is further characterized by its broadly oblong, subtetragonous, 4-valved anthers.

49. PIPER PHILIPPINUM Miq. Text figs. 56–58; Plate 17, fig. 6.

Piper philippinum MIQ., Syst. Pip. (1843) 322, Fl. Ind. Bat. 1^2 (1858–59) 453; C. DC., Prodr. 16^1 (1869) 348, Philip. Journ. Sci. 5 (1910) Bot. 437, Candollea 1 (1923) 190; F.-VILL., Novis. App. (1880)

[7] Inter. Rumph. Herb. Amb. (1917) 183.

175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

Piper lucbanense C. DC. in Leafl. Philip. Bot. 6 (1914) 2293, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Piper lividum C. DC. in Perk. Frag. Fl. Philip. (1905) 155, Philip. Journ. Sci. 5 (1910) Bot. 462, Candollea 1 (1923) 230; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper petraeum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 430, Candollea 1 (1923) 189; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

Piper crassilimbum C. DC., in Philip. Journ. Sci. 11 (1916) Bot. 210, Candollea 1 (1923) 187; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches glabrous, terete, 1.75 to 3.25 mm in diameter. Leaves chartaceous to subcoriaceous, elliptic-lanceolate, oblong-elliptic, subovate-elliptic, or subobovate-elliptic-ovate, 10 to 25 cm long, 4.5 to 11 cm wide, base equilaterally to subequilaterally acute to cordulate, 7-plinerved, apex shortly and acutely acuminate to acute, glabrous and shining on both surfaces, reticulations somewhat obscure above, prominent beneath; petioles glabrous, 6 to 23 mm long, in the lower leaves up to 30 mm long. Pistillate spikes oblong, 3 to 9 cm long, 8 to 12 mm in diameter; the peduncles glabrous, 6 to 20 mm long; rachis pilose, bracts sessile, peltate, disk glabrous, orbicular, 1 to 1.25 mm wide; fruits with base partly embedded in and concrescent with the rachis, subovoid-oblong to globose, umbonate, 2.75 to 3.25 mm long, 2.25 to 3 mm in diameter; stigmas 3, rarely 4, broadly ovoid, sessile, apical; seeds glabrous, oblong to globose, 2.5 to 3 mm long. Staminate spikes 5 to 12 cm long, 2 to 3 mm in diameter; the peduncles glabrous, 5 to 19 mm long; rachis densely pilose; bracts subpedicellate, peltate, 0.5 to 0.6 mm long, disk glabrous, orbicular, 1 to 1.25 mm wide; stamens 2, pedicellate, 0.5 to 0.75 mm long, anthers oblong to subglobose, 2-valved.

LUZON, Isabela Province, Malunu, *Warburg 11930* (type of *Piper lividum* C. DC. in herb. Berlin) : Benguet Subprovince, Baguio, *Merrill 7649* (type collection of *Piper crassilimbum* C. DC.), *7660*, *Sandkuhl 158;* Twin Peaks, *Elmer 6430* (type collection of *Piper petraeum* C. DC.) : Nueva Ecija Province, Mount Umingan, *Bur. Sci. 26347, 26393 Ramos and Edaño:* Cavite Province, Mendez, *Bur. Sci. 1316 Mangubat:* Rizal Province, without definite locality, *Loher 14799;* Santa Ines, *Bur. Sci. 26205 Ramos;* Mount Lumutan, *Bur. Sci. 29583 Ramos and Edaño;* Mount Irid, *Bur. Sci. 48428 Ramos and Edaño:* Laguna Province, Los Baños, Mount Maquiling, *Bur. Sci. 26913 Mabesa, Elmer 18010;* Mount Banahao, *Quisumbing 1261:* Tayabas Province, Lucban,

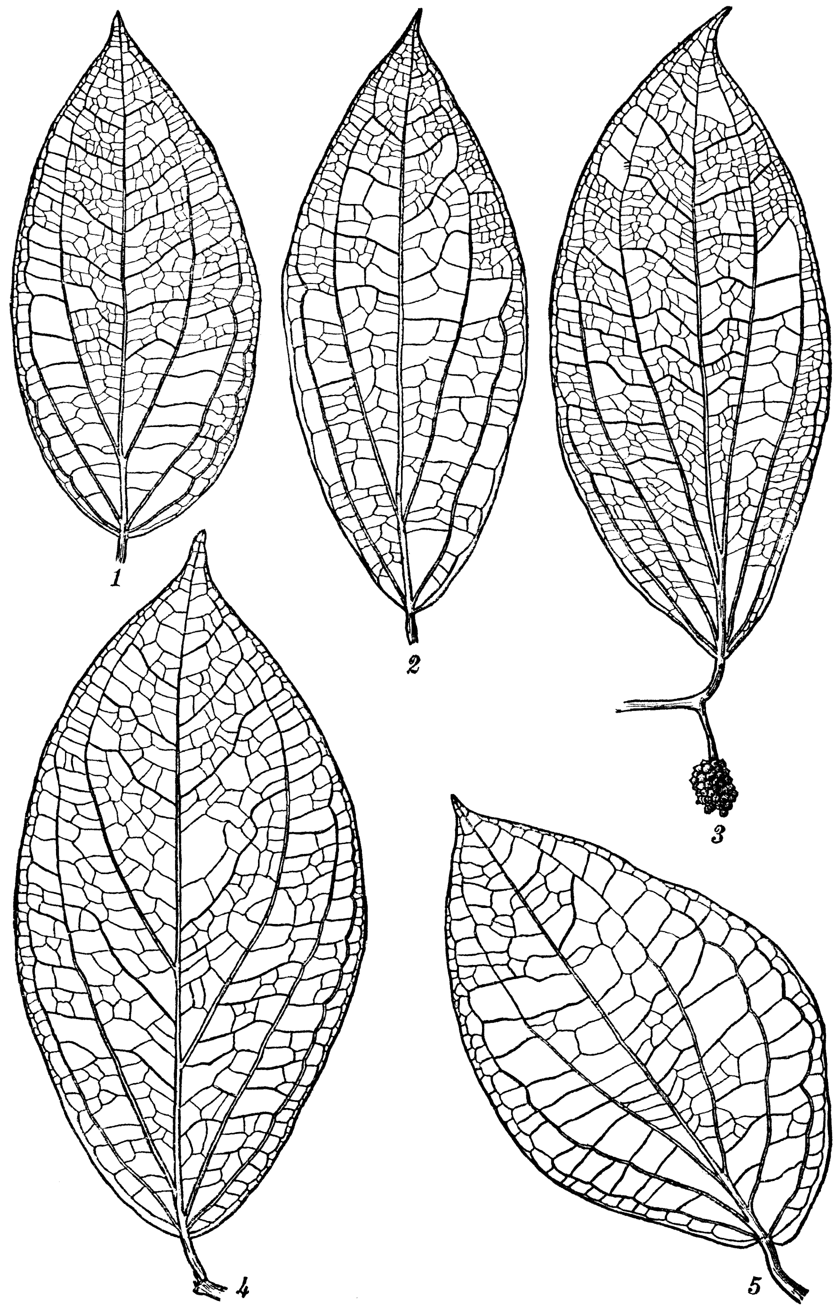


FIG. 56. *Piper philippinum* Miq.; *1–2, 4–5*, leaves, × 0.5; *3*, leaf and part of the pistillate spike, × 0.5.

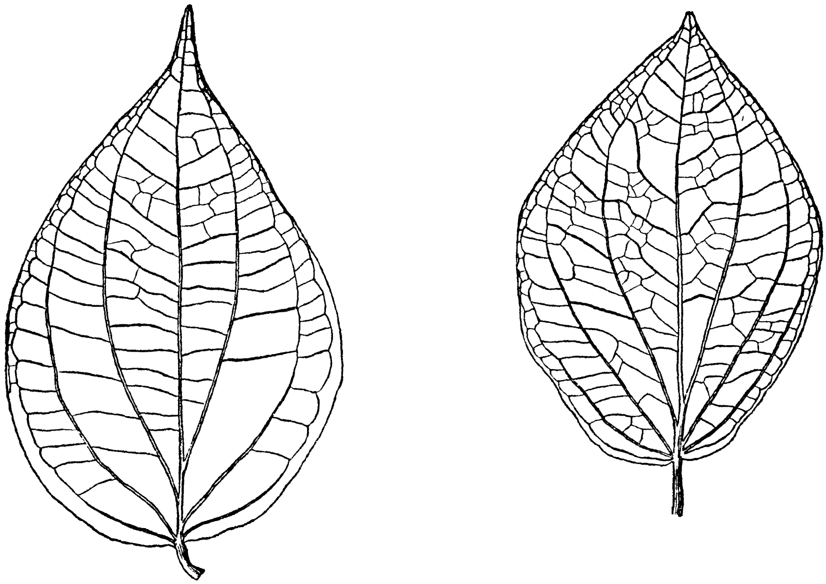


FIG. 57. *Piper philippinum* Miq.; leaves, × 0.5.

Elmer 7383 (type collection of *Piper lucbanense* C. DC.); hills near Malinao, *Baker 3249;* Malbug, *For. Bur. 29803 Gamalinda and Cohinhinan;* Mount Tulaog, *Bur. Sci. 29127, 29131 Ramos and Edaño:* Albay Province, without definite locality, *Cuming 912* (type of *Piper philippinum* Miq. in herb. de Less.; isotype in herb. Manila): Sorsogon Province, Irosin, Mount Bulusan, *Elmer 14377, 14432.* MASBATE, *Merrill 3050.* LEYTE, Tigbao, Tacloban, *Wenzel 1542, 1543.* PANAY, Antique Province, Culasi, *Bur. Sci. 32390, 32421, 32520 McGregor.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34363 Ramos and Pascasio;* Placer, *Wenzel 2606, 2949, 3250, 3252:* Bukidnon Province, Botoan, *Bur. Sci. 21398 Escritor:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13396, 13445:* Davao Province, Todaya, Mount Apo, *Elmer 11056:* Zamboanga Province, Mount Tubuan, *Bur. Sci. 36701 Ramos and Edaño.* In thickets and forests at low and medium altitudes, ascending to 1,550 meters. Endemic.

Local names: Buyo-buyo (S. L. Bis.); litlít (Buk.); palaybutó (Mag.).

Having examined the types and isotypes of all the synonyms above cited, and a great number of specimens, I can see no reason for distinguishing more than one species. This striking species, as well as *Piper albidirameum* C. DC. and *Piper maagnasanum*

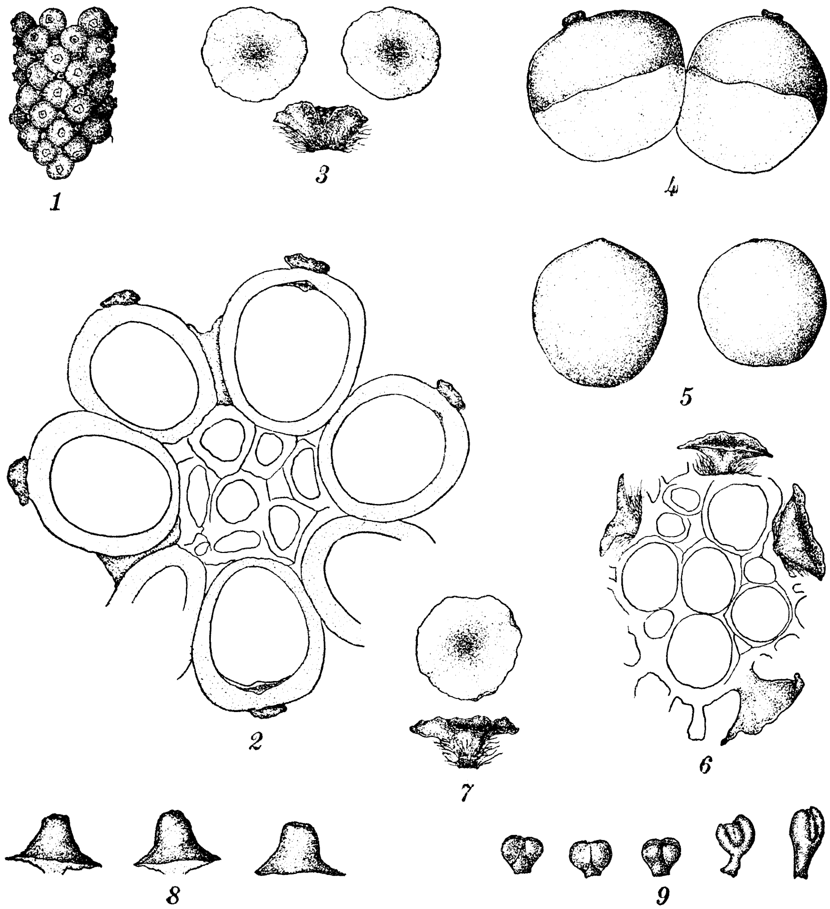


FIG. 58. *Piper philippinum* Miq.; *1*, portion of mature pistillate spike, × 1.5; *2*, transverse section of a mature pistillate spike, × 7.5; *3*, top and side views of pistillate bracts, × 10; *4*, fruits, × 7.5; *5*, seeds, × 7.5; *6*, transverse section of a staminate spike, × 10; *7*, top and side views of staminate bracts, × 10; *8*, sterile ovaries, × 10; *9*, stamens before and after dehiscence, × 10.

C. DC., is characterized by its unique staminate spikes, which are pseudohermaphroditic. While the ovaries are present in the staminate spikes, they do not develop as in the other hermaphroditic forms, and remain sterile. Two kinds of staminate spikes are found, one in which the stamens are more abundant than the sterile ovaries, and the other in which the sterile ovaries are more abundant than the stamens. In the latter case more stamens are found restricted somewhat at the apex of the spike. The stamens when young are sessile, becoming pedicellate at maturity of the spike. This species is also distinguished from

the group of species with the bases of the fruits partly embedded in and concrescent with the rachis by its leaves, the bases of which are sometimes cordulate and its larger fruits.

50. PIPER ALBIDIRAMEUM C. DC. Text fig. 59.

Piper albidirameum C. DC. in Perk. Frag. Fl. Philip. (1905) 153, Leafl. Philip. Bot. 3 (1910) 771, Philip. Journn. Sci. 5 (1910) Bot. 428, 11 (1916) Bot. 213, Candollea 1 (1923) 191; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper pendulifolium C. DC. in Leafl. Philip. Bot. 3 (1910) 772, Philip. Journ. Sci. 5 (1910) Bot. 429, Candollea 1 (1923) 191; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

A diœcious vine, the branches glabrous, terete, 3 to 6 mm in diameter. Leaves chartaceous to subcoriaceous, the younger ones membranaceous, broadly oblong-elliptic to broadly oblong-ovate, 14.5 to 28.5 cm long, 6.5 to 18 cm wide, base equilaterally to subequilaterally obtuse to cordulate, 7- to 9-plinerved, apex shortly and acutely or obtusely acuminate, glabrous and shining on both surfaces, reticulations distinct beneath; petioles rather stout, glabrous, 1.5 to 2.5 cm long. Pistillate spikes oblong to elongated oblong, 3 to 6.5 cm long, about 9 mm in diameter; the peduncles glabrous, 1 to 2 cm long; rachis pilose; bracts sessile, peltate, disk glabrous, orbicular, 0.75 to 1 mm wide; fruits with bases embedded in and concrescent with the rachis, subobovoid-globose, umbonate, 2.25 to 2.5 mm in diameter; stigmas 3 or 4, rounded-ovate, fleshy, sessile, apical; seeds glabrous, globose, 2 to 2.25 mm in diameter. Staminate spikes greatly elongated, cylindric, 7.5 to 17.5 cm long, 2 to 3 mm in diameter; the peduncles glabrous, 1 to 1.5 cm long; rachis pilose; bracts sessile, peltate, about 1.25 mm wide; stamens 2, sessile, anthers oblong, 2-valved.

LUZON, Apayao Subprovince, Ngagan, *Bur. Sci. 28059 Fénix:* Rizal Province, Bosoboso, *Bur. Sci. 1118 Ramos:* Laguna Province, Mount San Cristobal, *Juliano 1078:* Tayabas Province, Mount Binuang, *Bur. Sci. 28529 Ramos and Edaño:* Camarines Province, Adiagnao, *Bur. Sci. 6374 Robinson.* MINDORO, Palauan, *Bur. Sci. 39826 Ramos;* Pinamalayan, *Bur. Sci. 40896 Ramos.* SAMAR, Catubig River, *Bur. Sci. 24198 Ramos.* PANAY, Capiz Province, Jamindan, *Bur. Sci. 31094, 31241, 31356 Ramos and Edaño;* Libacao, *Bur. Sci. 31428 Ramos and Edaño;* Mount Timbaban, *Bur. Sci. 42368 Edaño:* Antique Province, Batbatan Island, *Bur. Sci. 32250 McGregor.* BOHOL, Valencia, *Bur. Sci. 42838, 43089, 43238 Ramos.* MINDANAO, Davao Province,

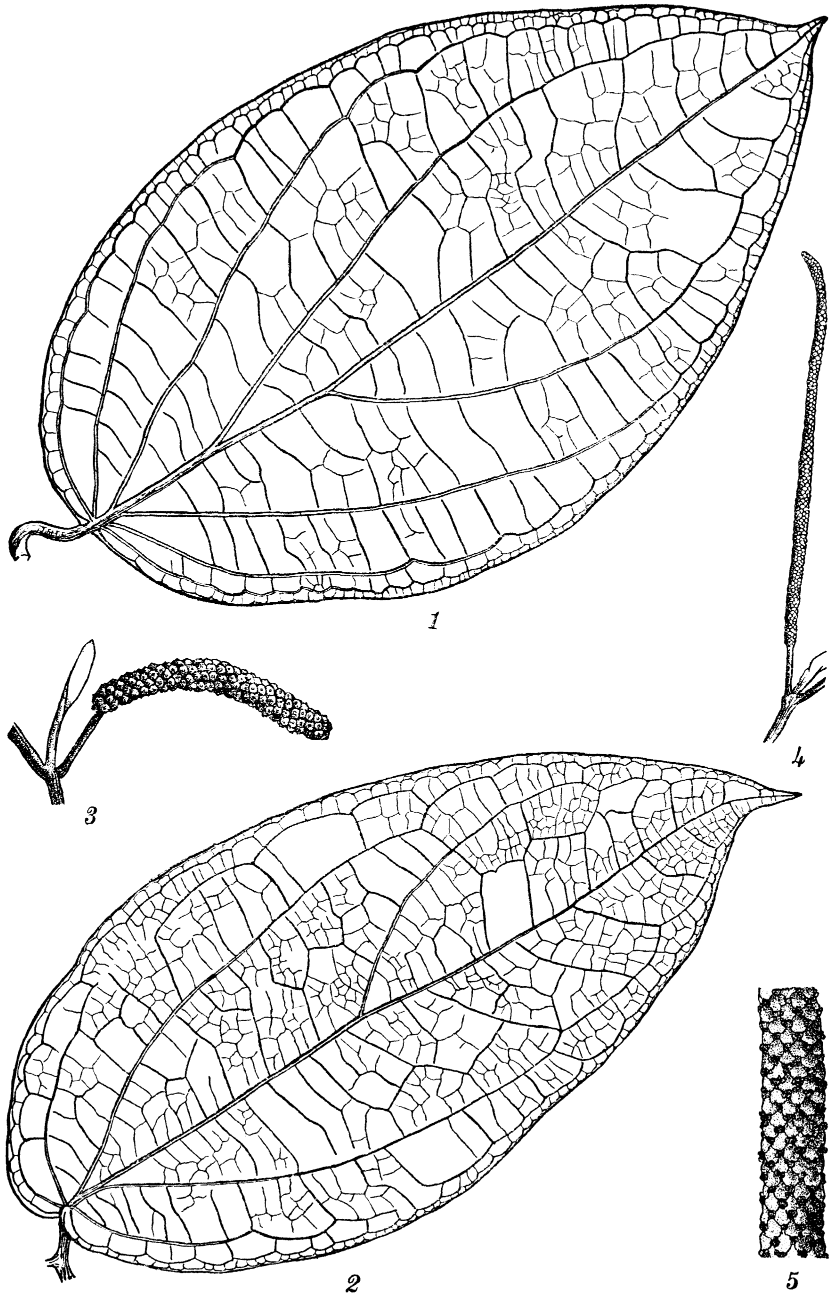


FIG. 59. *Piper albidirameum* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, staminate spike, × 0.5; *5*, portion of staminate spike, × 2.

Taumo, *Warburg 14751* (type of *Piper albidirameum* C. DC. in herb. Berlin); Todaya, Mount Apo, *Elmer 10942* (type collection of *Piper pendulifolium* C. DC.): Bukidnon Province, Impasuyong, *Wester 107*. In forests and thickets, at low altitudes, ascending to 700 meters. Endemic.

Local names: Kángal (Bag.); lakbaugan (Mbo.); lauiñgan (Buk.); litlít-kalabau (Mang.); makago (Mbo.); manikatapái (Bag.).

The pistillate spikes of this species resemble those of *Piper philippinum* Miq. This species is distinguished from *Piper philippinum* Miq. by its much larger broadly oblong-elliptic to broadly oblong-ovate leaves, with usually cordulate bases and by its much longer staminate spikes.

51. **PIPER MAAGNASANUM** C. DC. Text fig. 60.

Piper maagnasanum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 429, Candollea 1 (1923) 258; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper psilocarpum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 215, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper fuscescentirameum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 217, Candollea 1 (1923) 214; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

A diœcious vine, the branches glabrous, terete, 3 to 6.5 mm in diameter. Leaves chartaceous to coriaceous, broadly elliptic-ovate to broadly rounded-ovate, 14.5 to 35 cm long, 10.5 to 27.5 cm wide, base equilaterally to subequilaterally broadly acute to obtuse or broadly cordate, 9-plinerved, apex shortly and acutely or subobtusely acuminate, glabrous and shining on both surfaces, the nerves very prominent, reticulations distinct; petioles rather stout, glabrous, 10 to 43 mm long. Pistillate spikes elongated oblong, 2.8 to 6 cm long, 7 to 10 mm in diameter; the peduncles, rachis, fruits, bracts, and seeds similar to the preceding species; stigmas usually 3, fleshy. Staminate spikes and parts similar to preceding species.

LUZON, Ilocos Norte Province, Burgos, *Bur. Sci. 32899, 32929 Ramos:* Apayao Subprovince, Ngagan, *Bur. Sci. 28114 Ramos and Edaño:* Rizal Province, Mount Lumutan, *Bur. Sci. 29784 Ramos and Edaño:* Laguna Province, San Antonio, *Bur. Sci. 16597, 16630 Ramos;* Siniloan, *Bur. Sci. 23045 McGregor:* Tayabas Province, Atimonan, *Copeland and Campbell 6504;* Mount Dingalan, *Bur. Sci. 26621 Ramos and Edaño;* Infanta-Siniloan trail, *Bur. Sci. 29220 Ramos and Edaño;* Casiguran, *Bur. Sci. 45391 Ramos and Edaño:* Camarines Norte Province, Paracale,

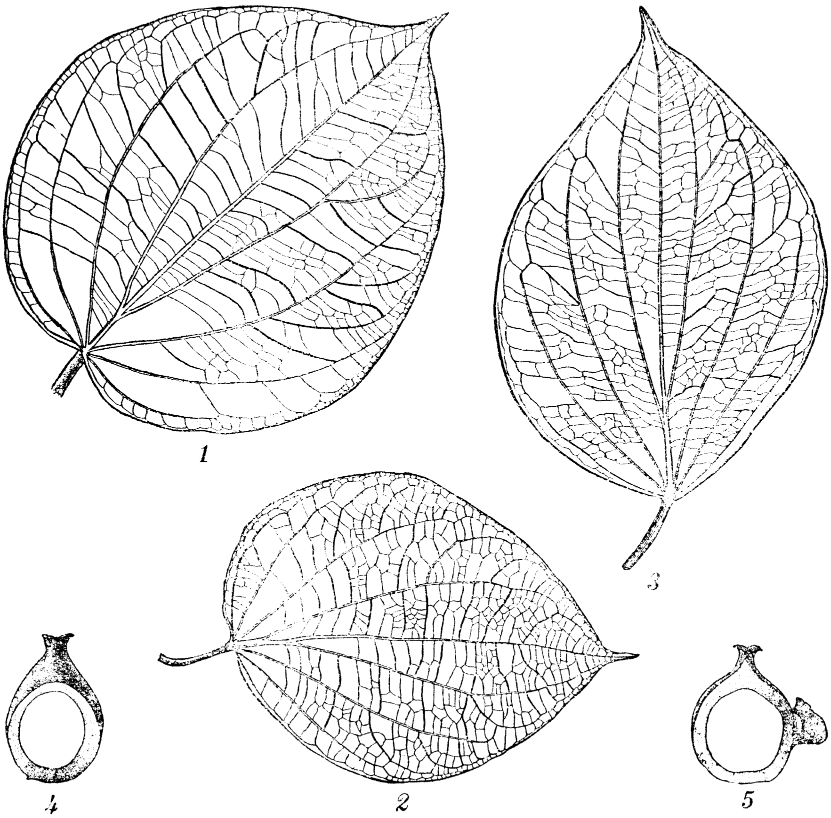


FIG. 60. *Piper maagnasanum* C. DC.; *1–3*, leaves, × 0.3; *4*, longitudinal section of a fruit, × 5; *5*, same with a bract attached, × 5.

Bur. Sci. 33522 Ramos and Edaño: Camarines Sur Province, Maagnas, *Bur. Sci. 6355 Robinson* (type collection of *Piper maagnasanum* C. DC.): Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16261;* Mount Bagacana, *Bur. Sci. 23558 Ramos.* ALABAT, Sangerin, *Bur. Sci. 48316 Ramos and Edaño.* SAMAR, Catubig River, *Merrill 11594.* LEYTE, Jaro, Buenavista, *Wenzel 896* (type collection of *Piper psilocarpum* C. DC.), *1006, 1151, 1184* (type collection of *Piper fuscescentirameum* C. DC.); Tigbao, *Wenzel 1288, 1478;* Cabalian, *Bur. Sci. 41597 Ramos.* MINDORO, Naujan, *Bur. Sci. 46438 Ramos.* BILIRAN, *Bur. Sci. 18706 McGregor.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34509 Ramos and Pascasio:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13309:* Davao Province, Mati, *Bur. Sci. 49132 Ramos and Edaño.* BUCAS GRANDE, *Bur. Sci. 35084 Ra-*

mos and Pascasio. Usually at low altitudes, but sometimes ascending to 500 meters. Endemic.

Local names: Gaúed (Ibn.); maragúm (Bis.).

This differs from *Piper albidirameum* C. DC. in its broadly elliptic-ovate to broadly rounded-ovate leaves. While in general the fruits resemble those of the preceding species, one finds also ovoid ones with prominent subacute apices and fairly pronounced rather short persistent styles.

52. PIPER ENSIFOLIUM sp. nov. Text fig. 61; Plate 11.

Frutex dioicus, scandens; ramulis glabris, 3 ad 4.5 mm diametro; foliis chartaceis, anguste lanceolatis, 15.5 ad 30 cm longis, 2 ad 3.4 cm latis, basi inaequilateralibus rotundato-auriculatis, 5- ad 7-plinerviis, apice acute attenuatis, utrinque gla-

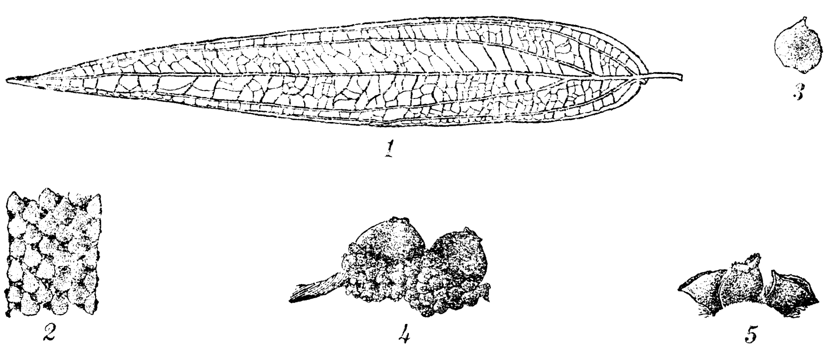


FIG. 61. *Piper ensifolium* sp. nov.; *1*, leaf, × 0.5; *2*, portion of a young pistillate spike, × 3; *3*, top view of a pistillate bract, × 7.5; *4*, portion of a pistillate spike, × 2; *5*, side view of pistillate bracts and an ovary, × 7.5.

bris; spicis ♀ oblongis, 3.5 ad 4 cm longis, 4 ad 6 mm diametro; pedunculis 1.5 ad 2.5 cm longis; rachis parcissime pilosis; bracteis pedicellatis, peltatis, 0.5 ad 0.8 mm longis, peltis subrotundato-ovatis, supra marginibusque glabris, 0.5 ad 1 mm latis, pedicellis ciliatis; fructibus liberis, basi partim immersis, globosis; stigmatibus 3, sessilibus, rotundatis, mamillatis.

A diœcious vine, the branches glabrous, terete, 3 to 4.5 mm in diameter. Leaves chartaceous, with glandular black dots beneath, narrowly lanceolate, 15.5 to 30 cm long, 2 to 3.4 cm wide, base inequilaterally rounded, auriculate, 5- to 7-plinerved, apex attenuate, acute, glabrous on both surfaces, more or less shining above; petioles glabrous, 1 to 2 mm long. Pistillate spikes pendulous, oblong, 3.5 to 4 cm long, 4 to 6 mm in diameter; the peduncles glabrous, 1.5 to 2.5 cm long; rachis slightly pilose;

bracts pedicellate, peltate, 0.5 to 0.8 mm long, disk glabrous, subrounded-ovate, 0.5 to 1 mm wide; fruits with their bases partly embedded in and concrescent with the rachis, glabrous, globose, 3 to 3.5 mm long, 2.5 to 3 mm in diameter; stigmas 3, rounded, mamillate.

LUZON, Tayabas Province, Casiguran, *Bur. Sci. 45433 Ramos and Edaño* (type in herb. Manila), May 29, 1925, in damp forests along streams, at low altitudes: Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 32991 Ramos* (sterile).

A species characterized by its narrowly lanceolate leaves with auriculate bases, and its mamillate stigmas.

53. PIPER CANINUM Blume. Text figs. 62, 1–2; 63, 7–8; 64, 1–3; 65, 1, 8–10; Plate 17, fig. 2.

Piper caninum BLUME in Verh. Bat. Genoots. 11 (1826) 214; A. DIETR., Sp. Pl. 1 (1831) 681; MIQ., Comm. Phyt. (1839) 17, 33, *t. 3;* C. DC., Prodr. 16^1 (1869) 341, Philip. Journ. Sci. 5 (1910) Bot. 458, 11 (1916) Bot. 224, Candollea 1 (1923) 225; F.-VILL., Novis. App. (1880) 175; VIDAL, Rev. Pl. Vasc. Filip. (1886) 219; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

Cubeba canina MIQ., Syst. Pip. (1843) 293.

Piper perpunctatum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 219, Candollea 1 (1923) 200; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branches puberulent, terete, 1.5 to 3 mm in diameter. Leaves chartaceous, oblong-ovate to ovate, 6 to 11 cm long, 3 to 6 cm wide, base equilaterally to subinequilaterally subacute to obtuse, the lower leaves subcordate to cordate, 5- to 7-plinerved, apex acutely acuminate, glabrous above, hirsute beneath, reticulations somewhat prominent on both surfaces; petioles hirtellous, 5 to 15 mm long, in the lower leaves up to 30 mm long. Pistillate spikes 3.5 to 4.5 cm long, about 1.5 cm in diameter; the peduncles hirsute, 10 to 20 mm long; rachis densely hirsute; bracts sessile, peltate, disk, orbicular, 0.5 to 1 mm wide, upper surface and margin ciliate; fruits pedicellate, glabrous, ellipsoid to ovoid-globose, 4 to 5 mm long, 3 to 3.5 mm in diameter, the pedicels glabrous, up to 5 mm in length; stigmas 3 or 4, rarely 2 or 5, ovoid, acute, sessile, apical. Staminate spikes slender, 10 to 20 mm long, 1 to 1.5 mm in diameter, the peduncles puberulent, 5 to 8 mm long; rachis hirsute; bracts subsessile, peltate, 0.3 to 0.4 mm long, disk glabrous above, margin ciliate, orbicular, about 0.5 mm wide; stamens 2, pedicellate, 0.5 to 0.75 mm long, anthers very small, globose, tetralocular, 2-valved, filaments as long as the anthers or slightly longer, exerted.

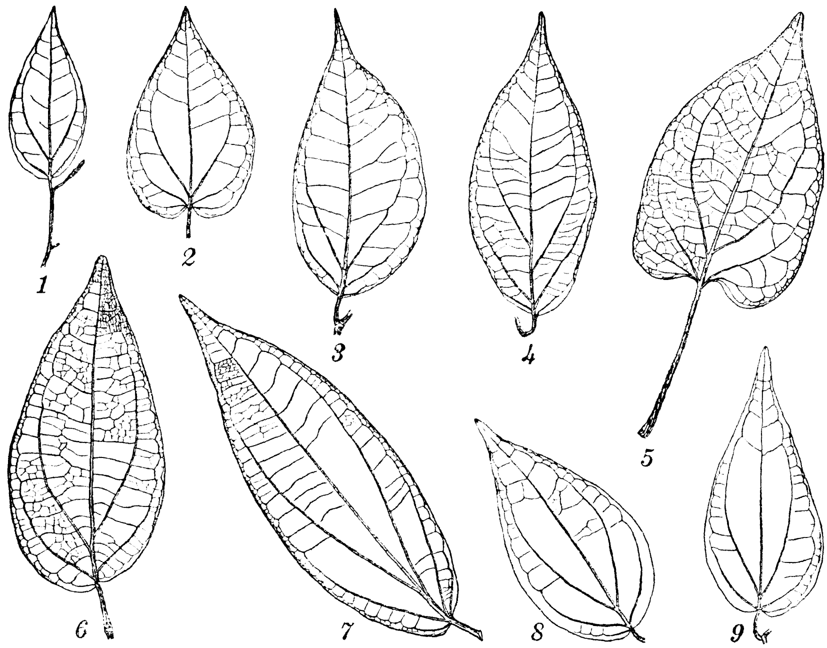


FIG. 62. Leaves of: *1–2*, *Piper caninum* Blume; *3*, var. *glabribracteum* C. DC.; *4–6*, var. *lanaoense* C. DC.; *7*, var. *oblongifolium* var. nov.; *8–9*, var *basilanum* C. DC. All × 0.3.

PALAWAN, Malampaya, *Merrill 7246* (type collection of *Piper perpunctatum* C. DC.); Lake Manguao, *Merrill 9462*. BUSUANGA, Bintuna, *Weber 1548bis*. In forests at low altitudes.

The widely distributed *Piper caninum* Blume was based on Javan material and extends from the Malay Peninsula to New Guinea. In the Philippines the species is represented by few collections only, from Palawan and Busuanga. *Piper perpunctatum* C. DC. (male) agrees in all essential characters with *Piper caninum* Blume, and is therefore reduced as a synonym. All varieties herein recorded are endemic to the Philippines, and have bracts which are glabrous above and on the margins.

Var. GLABRIBRACTEUM C. DC. Text figs. 62, 3; 64, 4; 65, 2.

Piper caninum BLUME var. *glabribracteum* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 459, Candollea 1 (1923) 225; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

Branches glabrous. Leaves ovate-lanceolate to oblong-subelliptic, 7 to 13.5 cm long, 3 to 6.5 cm wide, base equilaterally to subequilaterally acute to subobtuse, 5-plinerved, apex acutely acuminate, glabrous above, sparsely pilose beneath. Pistillate

spikes 2.5 to 4 cm long, the peduncles glabrous to hirtellous, 13 to 23 mm long; bracts sessile, peltate, disk rounded-obovate to orbicular, 0.75 to 1.25 mm wide; fruits ovoid-ellipsoid, 3.5 to 4.5 mm long, 3 to 4.5 mm in diameter.

MINDANAO, Surigao Province, Placer, *Wenzel 1815:* Lanao Province, Camp Keithley, Lake Lanao, *Clemens 176* (type of *Piper caninum* Blume var. *glabribracteum* C. DC. in herb. Manila), *Clemens s. n.:* Zamboanga Province, Malangas, *Bur. Sci. 37002 Ramos and Edaño.* In forests at low altitudes. Endemic.

This variety differs from the species principally by its glabrous bracts and the less pubescent lamina.

Var. LANAOENSE C. DC. Text figs. 62, 4-6; 64, 5; 65, 3.

Piper caninum Blume var *lanaoense* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 459, Candollea 1 (1923) 226; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

Branches glabrous to hirsute. Leaves oblong-elliptic to oblong-ovate, lower leaves heart-shaped, 8.5 to 14 cm long, 3.5 to 6.5 cm wide, base equilaterally subacute to rounded, 7-plinerved, apex acutely to subobtusely acuminate, slightly hirtellous on the nerves above, densely hirsute on the nerves beneath. Pistillate spikes 2.5 to 4.5 cm long, the peduncles glabrous, 1.5 to 1.8 cm long; bracts subsessile, peltate, disk suborbicular, 0.75 to 1.25 mm wide; fruits ovoid-globose, 3.5 to 4 mm long, 2.75 to 3.5 mm in diameter.

MINDORO, Pinamalayan, *Bur. Sci. 41073 Ramos.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34763 Ramos and Pascasio:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 14008:* Lanao Province, Camp Keithley, Lake Lanao, *Clemens s. n.,* Sept. 1906, (type of *Piper caninum* Blume var. *lanaoense* C. DC. in herb. Manila). JOLO, Bud-wak, *Link C-7.* CAMIGUIN DE MINDANAO, Mount Volcano, *Bur. Sci. 14672 Ramos.* In thickets and second-growth forests, at low and medium altitudes. Endemic.

This differs from the previous variety by its pubescence and form of the leaves.

Var. OBLONGIFOLIUM var. nov. Text figs. 62, 7; 64, 6; 65, 4.

Ramuli glabris ad sparse puberulis; foliis oblongis, 14 ad 17.5 cm longis, 4 ad 6.5 cm latis, basi subequilateralibus subobtusis, 7-plinerviis, apice obtuse acuminatis; bracteis subsessilibus, peltatis, peltis suborbicularis, 1 ad 1.25 mm latis; fructibus submaturis ovoideis, 4 ad 4.5 mm longis, 3 ad 3.5 mm diametro.

Branches glabrous to sparsely puberulent. Leaves oblong, 14 to 17.5 cm long, 4 to 6.5 cm wide, base subequilaterally subobtuse, 7-plinerved, apex obtusely acuminate, sparsely hirtellous on the nerves above, sparsely hirsute beneath. Pistillate spikes 1.5 to 2.5 cm long; the peduncles sparsely puberulent, 1.5 to 1.8 cm long; bracts subsessile, peltate, disk suborbicular, 1 to 1.25 mm wide; submature fruits ovoid, 4 to 4.5 mm long, 3 to 3.5 mm in diameter.

BUCAS GRANDE, *Bur. Sci. 35070 Ramos and Pascasio* (type of the variety in herb. Manila), June 8, 1919, in open forests at low altitudes.

Notwithstanding the marked foliar differences indicated, this plant shows such resemblances to *Piper caninum* Blume in inflorescence and other characters as to discourage its treatment as an independent species.

Var. HALLIERI (C. DC.) comb. nov. Text figs. 63, 1-2; 64, 7; 65, 5.

Piper hallieri C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 458, Candollea 1 (1923) 225; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

Branches sparsely hirsute. Leaves elliptic-lanceolate to elliptic-ovate, 10 to 13.5 cm long, 3 to 6.3 cm wide, base equilaterally acute, 5- to 7-plinerved, apex acutely acuminate, sparsely hirtellous on the nerves and parenchyma above, densely hirsute and

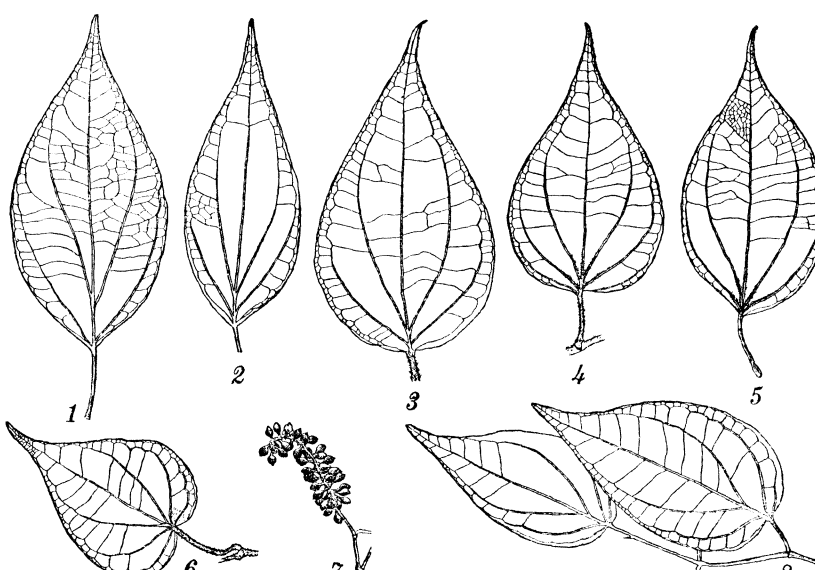


FIG. 63. *Piper caninum* Blume; *7*, pistillate spike; *8*, leaves. Var. *hallieri* (C. DC.) comb. nov.; *1–2*, leaves. Var. *latibracteum* C. DC.; *3–6*, leaves. All × 0.3.

glaucous beneath. Pistillate spikes 5 to 6.5 cm long; the peduncles sparsely hirsute, 2 to 2.5 cm long; bracts subsessile, peltate, disk orbicular to suborbicular, 0.75 to 1 mm wide; fruits obovoid-globose, 2.5 to 3.25 mm long, 2 to 2.25 mm in diameter, the pedicels up to 2.75 mm long.

BASILAN, *Hallier s. n.*, Jan., 1904 (type of *Piper hallieri* C. DC., in herb. Manila). Endemic.

Piper hallieri C. DC., which I have reduced as a variety, unquestionably belongs to the *Piper caninum* group and resembles somewhat *Piper dipterocarpinum* C. DC., differing in its pubescent leaves and much longer pistillate spikes.

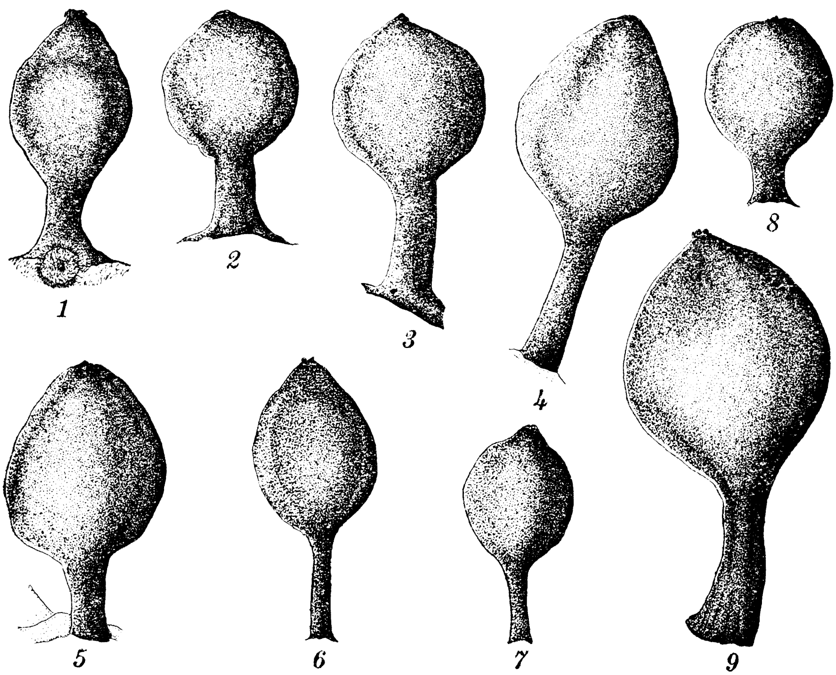


FIG. 64. Fruits of: *1–3*, *Piper caninum* Blume; *4*, var. *glabribracteum* C. DC.; *5*, var. *lanaoense* C. DC.; *6*, var. *oblongifolium* var. nov.; *7*, var. *hallieri* (C. DC.) comb. nov.; *8*, var. *basilanum* (C. DC.) comb. nov.; *9*, var. *latibracteum* C. DC. All × 5.

Var. BASILANUM (C. DC.) comb. nov. Text figs. 62, 8-9; 64, 8; 65, 6.

Piper basilanum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 457, Candollea 1 (1923) 226; MERR., Enum. Philip. Fl. Pl. 2 (1923) 4.

Branches glabrous, branchlets sparsely pilose. Leaves ovate to ovate-lanceolate, 8.5 to 11 cm long, 2.5 to 5 cm wide, base subequilaterally subrounded to rounded, 5-plinerved, apex obtusely acuminate, sparsely pubescent on the nerves and paren-

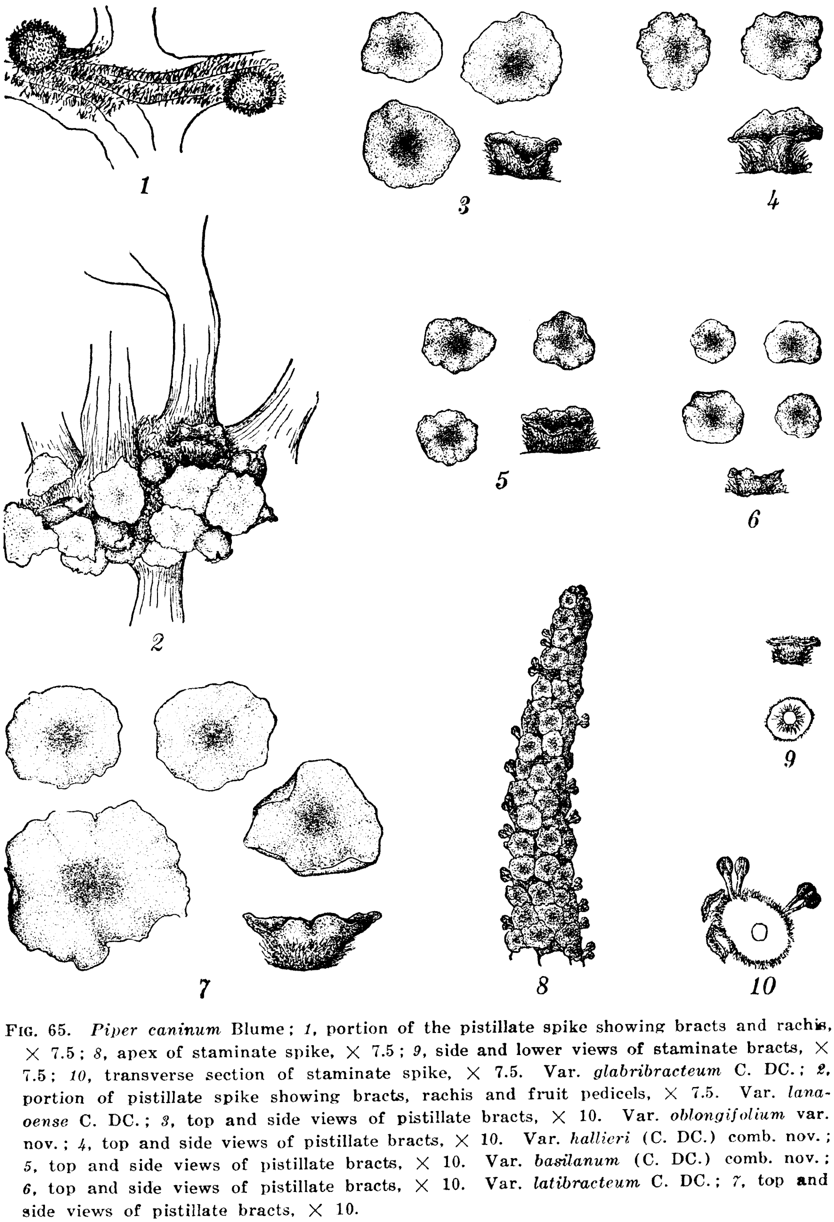


FIG. 65. *Piper caninum* Blume; *1*, portion of the pistillate spike showing bracts and rachis, × 7.5; *8*, apex of staminate spike, × 7.5; *9*, side and lower views of staminate bracts, × 7.5; *10*, transverse section of staminate spike, × 7.5. Var. *glabribracteum* C. DC.; *2*, portion of pistillate spike showing bracts, rachis and fruit pedicels, × 7.5. Var. *lanaoense* C. DC.; *3*, top and side views of pistillate bracts, × 10. Var. *oblongifolium* var. nov.; *4*, top and side views of pistillate bracts, × 10. Var. *hallieri* (C. DC.) comb. nov.; *5*, top and side views of pistillate bracts, × 10. Var. *basilanum* (C. DC.) comb. nov.; *6*, top and side views of pistillate bracts, × 10. Var. *latibracteum* C. DC.; *7*, top and side views of pistillate bracts, × 10.

chyma above, densely hirsute and glaucous beneath. Pistillate spikes 2 to 2.5 cm long; the peduncles glabrous, 1.8 to 2 cm long; bracts subsessile, peltate, disk orbicular, 0.5 to 0.75 mm wide; fruits subglobose, 3 to 3.5 mm long, 2.25 to 2.75 mm in diameter, the pedicels up to 1 mm long.

BASILAN, *Hallier s. n.*, Jan., 1904 (type of *Piper basilanum* C. DC. in herb. Manila). Endemic.

A variety very closely allied to *Piper caninum* Blume var. *hallieri* (C. DC.) Quis., but differing conspicuously in its relatively shorter pedicels.

Var. LATIBRACTEUM C. DC. Text figs. 63, 3-6; 64, 9; 65, 7.

Piper caninum Blume var. *latibracteum* C. DC. in Leafl. Philip. Bot. 3 (1910) 787, Philip. Journ. Sci. 5 (1910) Bot. 459, Candollea 1 (1923) 226; MERR., Enum. Philip. Fl. Pl. 2 (1923) 6.

Branches densely villose. Leaves ovate, 8.7 to 13.3 cm long, 4 to 7.2 cm wide, base equilaterally to subequilaterally subacute to obtuse, lower leaves cordate, 7-plinerved, apex long and acutely acuminate, sparsely pubescent above, densely pubescent beneath. Pistillate spikes 2.3 to 5 cm long; the peduncles villose, 1.5 to 2.5 cm long; bracts sessile to subsessile, peltate, disk orbicular, 1.25 to 2 mm wide; fruits ovoid-globose, 5 to 6 mm long, 3.5 to 4.75 mm in diameter.

LUZON, Benguet Subprovince, Baguio, *Elmer 8844:* Nueva Ecija Province, Mount Umingan, *Bur. Sci. 26502 Ramos and Edaño:* Tayabas Province, Lucban, *Elmer 7990* (type collection of *Piper caninum* Blume var. *latibracteum* C. DC.). On stream banks and in forests at medium altitudes, and ascending to 1,300 meters. Endemic.

A variety close to *Piper sablanum* (C. DC.) Quis., differing in its villose branches, petioles, and peduncles, its leaves being pubescent on both surfaces, and in its large, ovoid-globose fruits.

54. PIPER VIMINALE Opiz. Text figs. 66 and 67.

Piper viminale OPIZ in Presl. Rel. Haenk. 1 (1828) 150, *t. 26, f. 1;* MIQ., Syst. Pip. (1843) 336; C. DC., Prodr. 16^1 (1869) 337, Philip. Journ. Sci. 5 (1910) Bot. 436, 11 (1916) Bot. 217, Candollea 1 (1923) 197; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Chavica? viminalis MIQ., in Linnaea 20 (1847) 131, Fl. Ind. Bat. 1^2 (1858–59) 445.

Piper negrosense C. DC. in Leafl. Philip. Bot. 3 (1910) 786, Philip. Journ. Sci. 5 (1910) Bot. 454, Candollea 1 (1923) 222; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper marivelesanum C. DC. in Perk. Frag. Fl. Philip. (1905) 155, Leafl. Philip. Bot. 3 (1910) 787, Philip. Journ. Sci. 5 (1910) Bot. 457, 11 (1916) Bot. 224, Candollea 1 (1923) 221, 223, 226; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Piper tenuirameum C. DC. in Perk. Frag. Fl. Philip. (1905) 159, Philip. Journ. Sci. 5 (1910) Bot. 456, Candollea (1923) 281; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

Piper parcipilum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 445, Candollea 1 (1923) 211; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

A diœcious vine; the young branches hirtellous, older ones glabrous, terete, 1 to 2.5 mm in diameter. Leaves chartaceous, in the male narrowly linear to narrowly oblong-ovate or narrowly ovate-lanceolate, 3.5 to 14.5 cm long, usually 0.5 to 2 cm wide, in the lower leaves up to 4.5 cm wide, in the female oblong-ovate to oblong-lanceolate, 6 to 14.5 cm long, 2 to 6 cm wide, lower leaves in both male and female ovate-lanceolate to ovate, base equilaterally to inequilaterally subacute to rounded, 3- to 5-plinerved, in the lower leaves in both male and female usually subrounded to cordate, narrowed to the subobtuse apex, in the male glabrous on both surfaces to hirtellous on the midrib of one or both surfaces to rarely hirtellous on the nerves beneath, in the female glabrous to hirtellous on the nerves above, hirsute beneath or on the nerves only, reticulations somewhat obscure above, more or less prominent beneath; petioles hirtellous, 2 to 10 mm long, in the lower leaves up to 30 mm in length. Pistillate spikes 1.5 to 4 cm long, 1 to 1.5 cm in diameter; the peduncles hirtellous, 12 to 25 mm long, rarely 30 mm long; rachis hirsute; bracts sessile to subsessile, fleshy, peltate, disk glabrous above, ciliate on the margins, orbicular, 0.75 to 1 mm wide; fruits pedicellate, ovoid to globose, 3 to 4.5 mm long, 2.5 to 4 mm in diameter, glabrous, the pedicels up to 5 mm long; stigmas 3 or 4, ovoid, acute, sessile, apical. Staminate spikes slender, 7.5 to 15 mm long, 1 to 1.5 mm in diameter; the peduncles hirtellous, 5 to 11 mm long; rachis densely hirsute; bracts subsessile, fleshy, peltate, disk glabrous above, ciliate on the margins, orbicular, 0.5 to 1 mm wide; stamens 2, pedicellate, anthers small, ovoid, bilocular, 2-valved, filaments longer than the anthers, slender, exerted.

LUZON, without definite locality, *Haenke s. n.* (type of *Piper viminale* Opiz, in herb. Prague) : Isabela Province, Peñablanca, *Warburg 12126;* San Mariano, *Bur. Sci. 46989 Ramos and Edaño:* Pangasinan Province, Mount San Isidro, *Bur. Sci. 29913 Fénix:* Benguet Subprovince, Sablan, *Elmer 6161;* Baguio, *Elmer 8886:* Zambales Province, Subic, *Bur. Sci. 38315 Edaño:* Bataan Province, Mount Mariveles, *Warburg 13640* (type collection of *Piper marivelesanum* C. DC.), *Merrill 3727, Williams 227, 369, 370, Whitford 1060, For. Bur. 165 Barnes, 1756 Borden, 2507 Meyer;* Dinalupihan, *Merrill 1579;* Limay, *For. Bur. 19158 Curran:* Bulacan Province, Angat, *Bur. Sci. 34036 Ramos and*

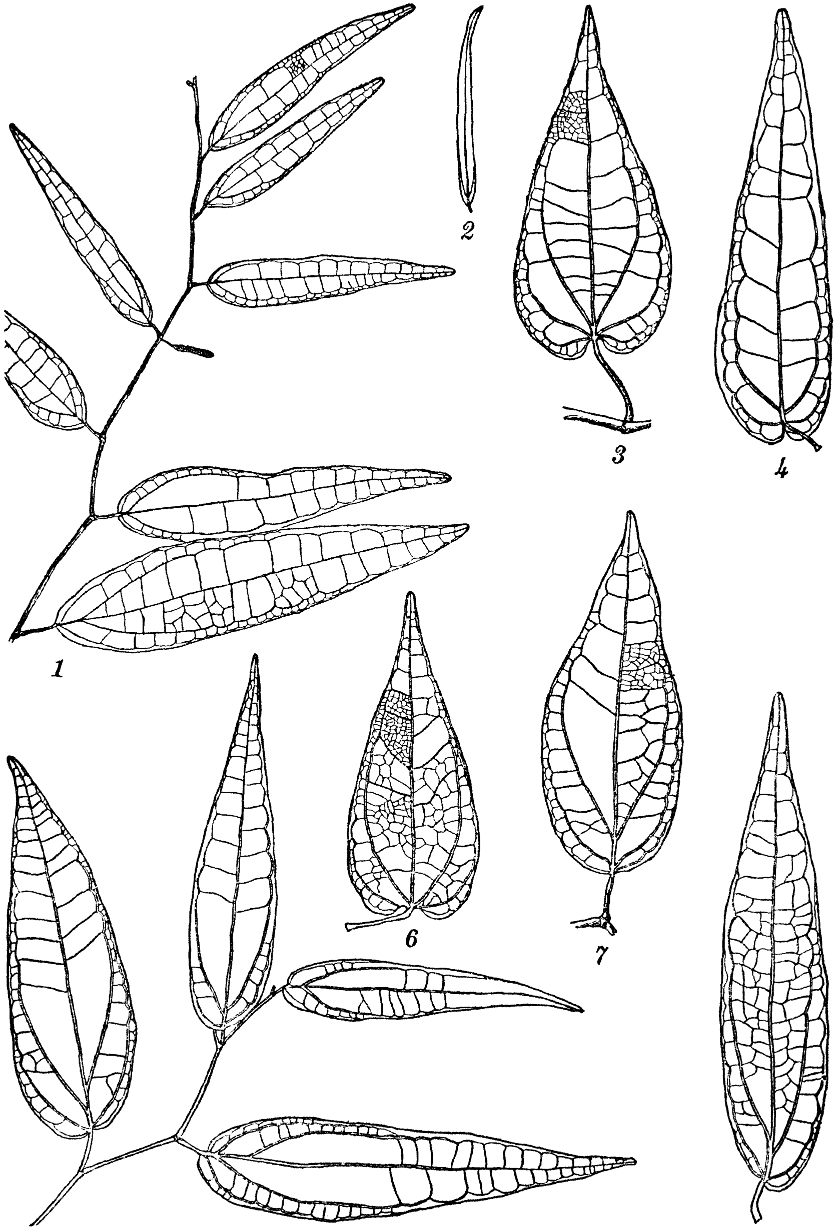


FIG. 66. *Piper viminale* Opiz; *1*, branch of the male plant; *2*, upper leaf of male plant; *3*, lower leaf; *4*, leaf; *5*, branch of the female plant; *6*, lower leaf; *7–8*, leaves. All × 0.5.

Edaño: Rizal Province, Bosoboso, *Bur. Sci. 1115 Ramos;* Binangonan, *Warburg 13317* (type collection of *Piper tenuirameum* C. DC.) : Laguna Province, San Antonio, *Bur. Sci. 10952, 12021,*

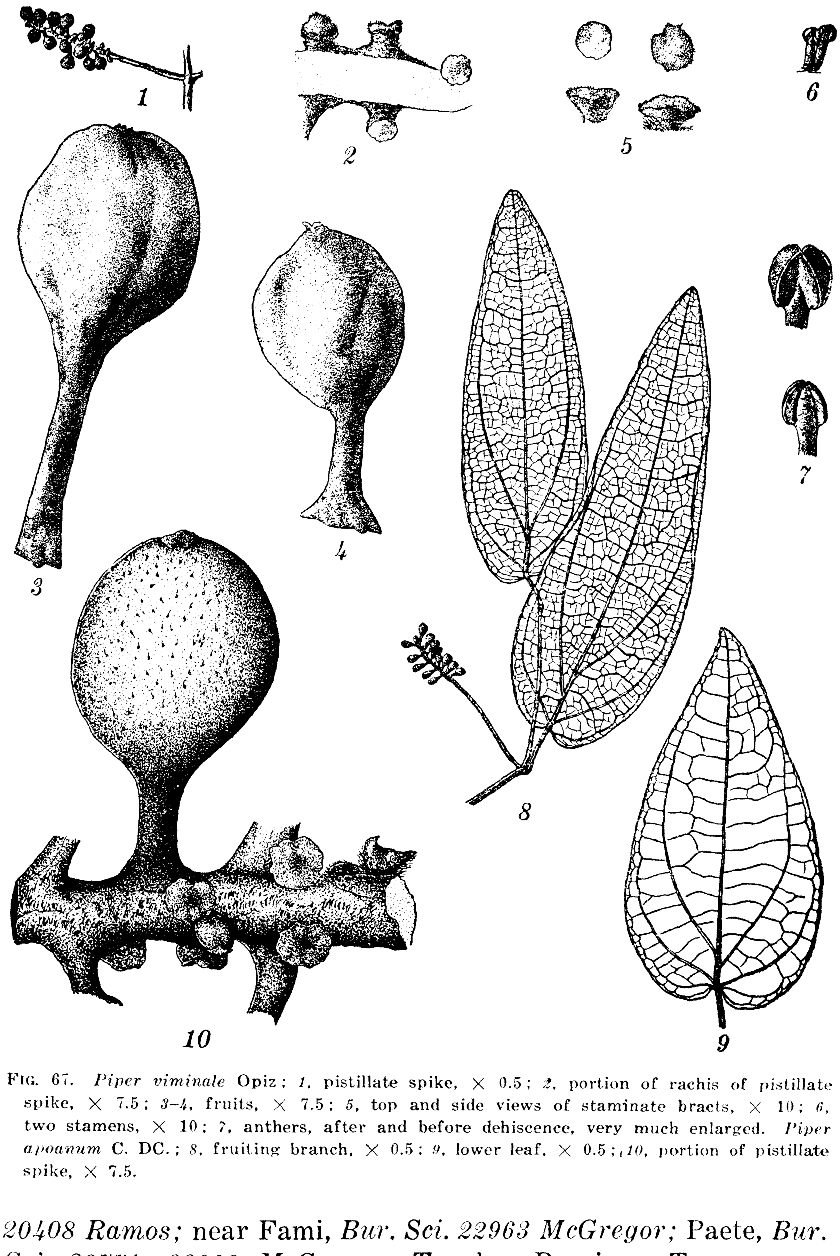


FIG. 67. *Piper viminale* Opiz; *1*, pistillate spike, × 0.5; *2*, portion of rachis of pistillate spike, × 7.5; *3–4*, fruits, × 7.5; *5*, top and side views of staminate bracts, × 10; *6*, two stamens, × 10; *7*, anthers, after and before dehiscence, very much enlarged. *Piper apoanum* C. DC.; *8*, fruiting branch, × 0.5; *9*, lower leaf, × 0.5; *10*, portion of pistillate spike, × 7.5.

20408 Ramos; near Fami, *Bur. Sci. 22963 McGregor;* Paete, *Bur. Sci. 22774, 23009 McGregor:* Tayabas Province, Tagcauayan, *Bur. Sci. 13349 Ramos;* Dolores, *For. Bur. 30063 Sulit;* Lucban-Mauban road, *Bur. Sci. 47392 McGregor;* Infanta-Siniloan trail, *Bur. Sci. 29194 Ramos and Edaño:* Camarines Norte Province,

Niog, Sagnay, *Bur. Sci. 22133 Ramos;* Paracale, *Bur. Sci. 33690 Ramos and Edaño:* Camarines Sur Province, Maagnas, *Bur. Sci. 6327 Ramos:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16944.* POLILLO, Mount Malulud, *Bur. Sci. 9213 Robinson;* Barrio Saloang, *For. Bur. 29665 Salvoza.* CATANDUANES, Mount Mariguidon, *Bur. Sci. 30241, 30513 Ramos and Chan;* Santo Domingo River, *Bur. Sci. 30560 Ramos and Chan.* MINDORO, Bongabong River, Camantigue, *For. Bur. 3668 Merritt;* Mount Calavite, *Bur. Sci. 39407 Ramos and Lopez;* Paluan, *Bur. Sci. 39672 Ramos and Lopez.* SAMAR, Mount Canislagan, *Bur. Sci. 17508 Ramos;* Camaniwan, Catubig River, *Bur. Sci. 24260 Ramos.* LEYTE, Dagami, *Wenzel 307;* Jaro, Buenavista, *Wenzel 856;* Tigbao, Tacloban, *Wenzel 1618.* PANAY, Antique Province, Culasi, *Bur. Sci. s. n. McGregor* (field No. *McGregor 5711*) : Capiz Province, Magallanes, Mount Giting-giting, *Elmer 12212;* Jamindan, *Bur. Sci. 31131, 31266, 31339 Ramos and Edaño.* NEGROS, Negros Oriental Province, Dumaguete, Cuernos Mountains, *Elmer 9482* (type collection of *Piper negrosense* C. DC.). PALAWAN, Malampaya, *Merrill 7213.* MINDANAO, Surigao Province, Surigao, *Piper 244, Bur. Sci. 34389 Ramos and Pascasio;* Placer, *Wenzel 2785, 3099:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 14253:* Davao Province, Davao, *Copeland 501:* Lanao Province, Camp Keithley, Lake Lanao, *Clemens s. n.* 1906 (type of *Piper parcipilum* C. DC. in herb. Manila) : Zamboanga Province, Malangas, *Bur. Sci. 37105 Ramos and Edaño.* BUCAS GRANDE, *Bur. Sci. 35080 Ramos and Pascasio.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14645, 14676, 14685, 14699 Ramos.* In thickets and forests at low and medium altitudes, ascending to 1,000 meters. Endemic.

Local names: Buyók-hálo (P. Bis.) ; lauiñgan (Sub.) ; lauiñgan-ihalas (Bis.) ; litlít-matsing (Tag.) ; súbong-manók (Tag.) ; subú-manók (Tag.) ; tubóg-manók (Tag.).

This species is clearly allied to *Piper caninum* Blume, but differs in the form and size of its leaves, particularly the male plant. The female plant is more similar to Blume's species, differing in the form of its leaves and its pistillate fleshy bracts, which are sometimes subsessile; *Piper negrosense* C. DC. is unquestionably the same as *Piper viminale* Opiz. Likewise, *Piper marivelesanum* C. DC., *Piper tenuirameum* C. DC., and *Piper parcipilum* C. DC. are not distinct from *Piper viminale* Opiz, as herewith interpreted.

55. PIPER APOANUM C. DC. Text fig. 67, 8–10.

Piper apoanum C. DC. in Leafl. Philip. Bot. 3 (1910) 785, Philip. Journ. Sci. 5 (1910) Bot. 454, Candollea 1 (1923) 222; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

A diœcious vine; the branches glabrous, terete, 1.5 to 2 mm in diameter. Leaves chartaceous, oblong-ovate, 10.5 to 14.5 cm long, 3.2 to 5.5 cm wide, base equilaterally to subequilaterally subcordate, the lower leaves cordate, 5-plinerved, narrowed to the obtuse apex, glabrous on both surfaces, reticulations somewhat obscure on both surfaces; petioles puberulent, 8 to 12 mm long. Pistillate spikes somewhat pendulous, 2 to 3 cm long, 10 to 13 mm in diameter; the peduncles glabrous, about 3 cm long; rachis hirtellous; bracts subsessile, peltate, 0.5 to 0.75 mm wide, disk glabrous above and on the margins, fleshy, orbicular, 0.75 to 1 mm wide, pedicels stout, fleshy, densely and minutely hirtellous; fruits pedicellate, not crowded, subglobose, 3 to 4 mm long, 3 to 3.5 mm in diameter, glandular, puberulent, black when dry, the pedicels sparingly hirtellous, up to 2 mm in length; stigmas 3, ovoid, sessile, apical.

MINDANAO, Davao Province, Mount Apo, *Elmer 11174* (type collection), in thickets, altitude about 800 meters. Endemic.

Local name: Manikatápai (Bag.).

This species is close to *Piper viminale* Opiz, but differs in its leaves with subcordate to cordate bases, its puberulent fruits, and hirtellous rachis.

56. PIPER DENSIBACCUM C. DC. Text fig. 68.

Piper densibaccum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 454, Candollea 1 (1923) 222; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

A diœcious vine; the branches tomentose, terete, 1.5 to 2.5 mm in diameter. Leaves chartaceous, oblong, 7.5 to 11 cm long, 2.7 to 4.5 cm wide, base equilaterally to subequilaterally acute to obtuse, 5-plinerved, apex obtusely acuminate, glabrous on both surfaces, reticulations more or less prominent on both surfaces; petioles tomentose, 10 to 13 mm long, in the lower leaves up to 30 mm in length. Pistillate spikes pendulous, 2.5 to 4 cm long, about 1.3 cm in diameter; the peduncles glabrous, 1.7 to 2 cm long; rachis densely hirsute; bracts subsessile, peltate, disk glabrous above and on the margins, membranaceous, orbicular, 1 to 1.25 mm wide; fruits pedicellate, crowded, ellipsoid to subglobose, 3 to 4 mm long, 2.5 to 3.5 mm in diameter, glabrous, black when dry, the pedicels glabrous, up to 2.5 mm long; stigmas 3 or 4, ovoid, sessile, apical.

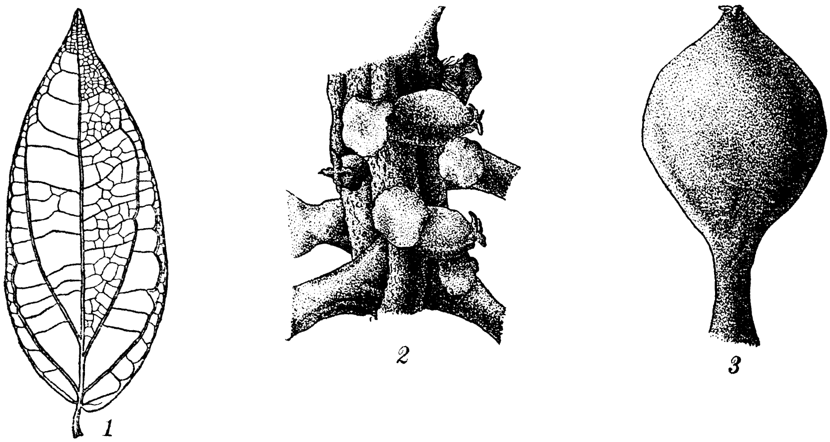


FIG. 68. *Piper densibaccum* C. DC.: *1*, leaf, × 0.5; *2*, portion of the pistillate spike, × 7.5; *3*, fruit, × 7.5.

MINDANAO, Lanao Province, Camp Keithley, Lake Lanao, *Clemens s. n.*, 1906 (type in herb. Manila). Endemic.

In some respects this resembles *Piper apoanum* C. DC., differing in its oblong leaves, ellipsoid to subglobose, glabrous fruits, and its tomentose branches.

57. PIPER DAGATPANUM C. DC. Text fig. 69.

Piper dagatpanum C. DC. in Perk. Frag. Fl. Philip. (1905) 154, Philip. Journ. Sci. 5 (1910) Bot. 455, Candollea 1 (1923) 223; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches glabrous, terete, 1.5 to 2 mm in diameter. Leaves chartaceous, oblong-ovate, 10.5 to 14.5 cm long, 3.5 to 7.5 cm wide, lower leaves ovate, base inequilaterally subacute to subrounded, in the lower leaves subcordate, 7-plinerved, apex acute, glabrous on both surfaces, reticulations somewhat obscure on both surfaces; petioles glabrous, 1.3 to 1.8 cm long. Pistillate spikes pendulous, 5 to 6.5 cm long, 1.2 to 1.4 cm in diameter; the peduncles glabrous, 2 to 2.5 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous above and on the margins, membranaceous, oblong-obovate to orbicular, 0.75 to 1 mm wide; fruits pedicellate, somewhat remote, subglobose, 4 to 5.5 mm long, 3.5 to 4 mm in diameter, glabrous, reddish black when dry, the pedicels sparingly hirtellous at the base, up to 3 mm long; stigmas 4, oblong, sessile, apical.

MINDANAO, Davao Province, Mount Dagatpan, *Warburg 14739* (type in herb. Berlin; isotype in herb. Manila): Zamboanga

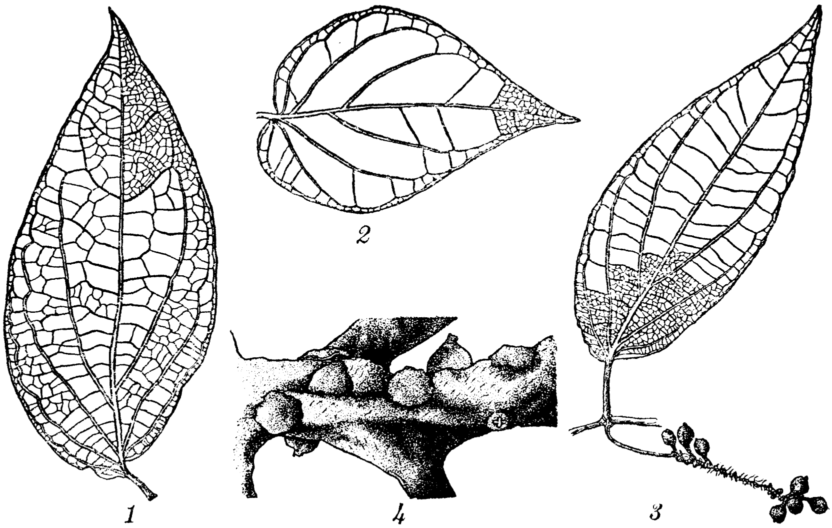


FIG. 69. *Piper dagatpanum* C. DC.; *1*, leaf, × 0.5; *2*, lower leaf, × 0.5; *3*, leaf and pistillate spike, × 0.5; *4*, portion of the pistillate spike, × 7.5.

Province, Sibulan, *Warburg 14738*. In forests, altitude about 1,300 meters. Endemic.

This species possesses the habit and many characteristics of *Piper apoanum* C. DC., occurs in the same region, and is doubtless related to it. However, it differs in its acute leaves, and glabrous petioles, bracts, and fruits.

58. **PIPER DIPTEROCARPINUM C. DC. Text fig. 70.**

Piper dipterocarpinum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 455, Candollea 1 (1923) 222; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Piper malindangense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 436, Candollea 1 (1923) 195; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

A diœcious vine; the branches glabrous, terete, 1.25 to 2 mm in diameter. Leaves chartaceous, oblong-elliptic, 10 to 12.7 cm long, 2.5 to 5 cm wide, lower leaves ovate, base equilaterally to subequilaterally acute, 5- to 7-plinerved, apex long and acutely acuminate, glabrous on both surfaces, reticulations somewhat obscure on both surfaces; petioles glabrous, 4 to 13 mm long. Pistillate spikes suberect, 2 to 3 cm long, about 1 cm in diameter; the peduncles glabrous, about 1.3 cm long; rachis densely hirsute; bracts sessile, peltate, disk glabrous above and on the margins, orbicular, about 0.75 mm wide; fruits pedicellate, somewhat crowded, subglobose, about 3 mm long, 2.5 mm in diameter, glabrous, glandular, the pedicels glabrous and spar-

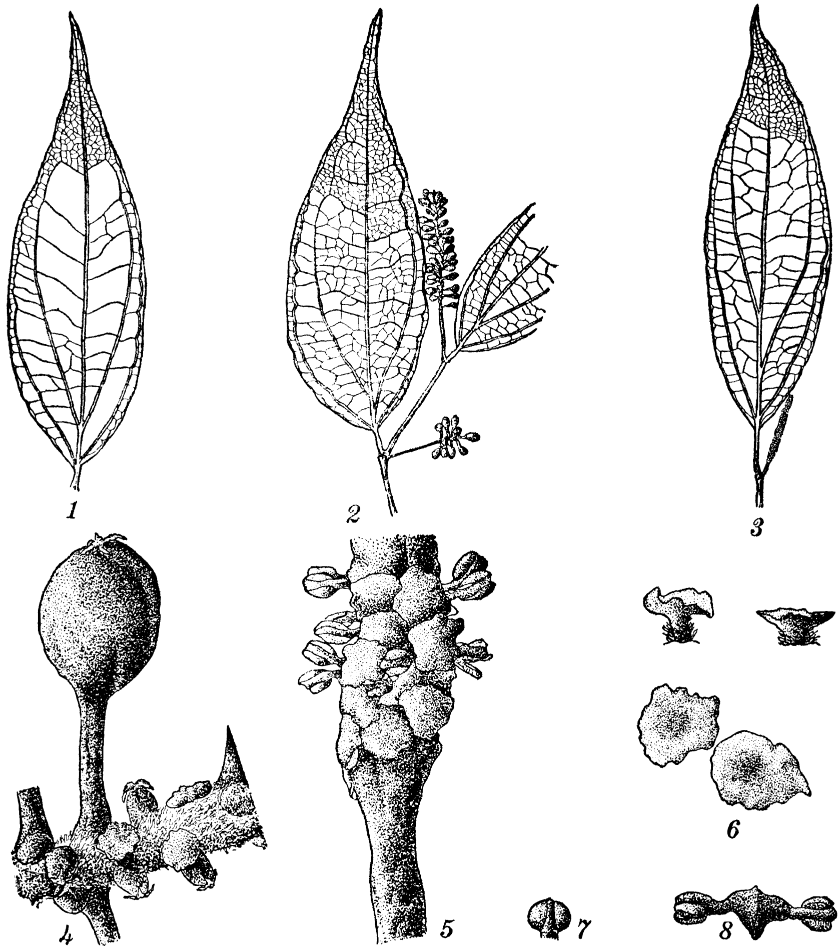


FIG. 70. *Piper dipterocarpinum* C. DC.; *1*, leaf, × 0.5; *2*, fruiting branch of pistillate plant, × 0.5; *3*, leaf and staminate spike, × 0.5; *4*, portion of pistillate spike, × 7.5; *5*, portion of staminate spike, × 7.5; *6*, side and top views of staminate bracts, × 10; *7*, stamen, before dehiscence, × 10; *8*, stamens, after dehiscence, × 10.

ingly glandular, up to 3 mm in length; stigmas 4 or 5, lanceolate, apex acute, sessile, apical. Staminate spikes suberect, slender, 2 to 5 cm long, 1.25 to 2 mm in diameter; the peduncles glabrous, 2 to 7 mm long; rachis hirsute; bracts pedicellate, peltate, 0.3 to 0.5 mm long, disk glabrous above and on the margins, crenate, orbicular, 0.75 to 1.25 mm wide; stamens 2, pedicellate, about 0.75 mm long, anthers oblong or subglobose, 2-valved, filaments exerted.

MINDANAO, Misamis Province, Mount Malindang, *For. Bur. 4758 Mearns and Hutchinson* (type of *Piper malindangense* C. DC. in herb. Manila): Lanao Province, Camp Keithley, Lake Lanao, *Clemens s. n.*, 1906: Zamboanga Province, Banga, *For. Bur. 9146 Whitford and Hutchinson* (type of *Piper dipterocarpinum* C. DC. in herb. Manila). BASILAN, Binauangan, *Bur. Sci. 15465 Reillo.* In forests at low altitudes. Endemic.

This species is allied to *Piper caninum* Blume, from which it is distinguished by its oblong-elliptic leaves, which are glabrous on both surfaces; by its pistillate bracts, which are glabrous on the surfaces and on the margins, and by its much longer staminate spikes.

59. PIPER SABLANUM (C. DC.) comb. nov. Text fig. 71.

Piper caninum Blume. var. *sablanum* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 459, Candollea 1 (1923) 244; MERR., Enum. Philip. Fl. Pl. 2 (1923) 6.

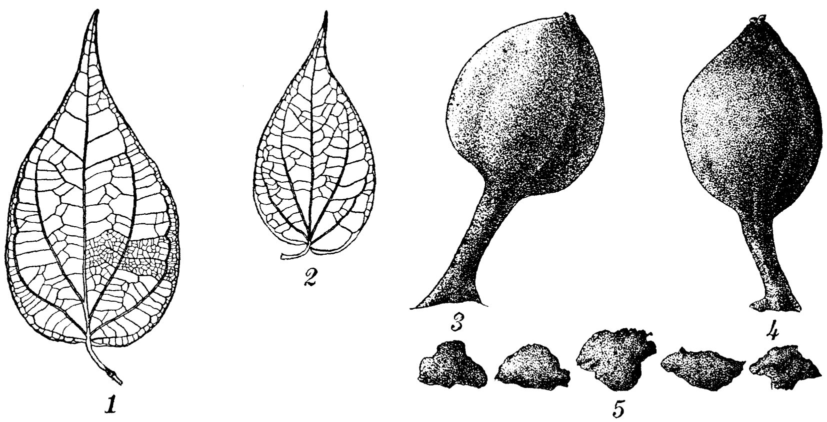


FIG. 71. *Piper sablanum* (C. DC.) comb. nov.; *1–2*, leaves, × 0.3; *3–4*, fruits, × 5; *5*, top and side views of pistillate bracts, × 5.

A diœcious vine; the branches usually glabrous, rarely hirtellous, terete, 2 to 3 mm in diameter. Leaves chartaceous, ovate, 8 to 13.5 cm long, 4.5 to 7 cm wide, base equilaterally to subequilaterally rounded, 7-plinerved, apex long and acutely acuminate, glabrous above, sparsely hirsute beneath, reticulations somewhat prominent on both surfaces; petioles hirtellous, 10 to 15 mm long, in the lower leaves up to 30 mm in length. Pistillate spikes 2.5 to 3 cm long, 1.8 to 2 cm in diameter; the peduncles glabrous to sparsely hirtellous, 2 to 3 cm long, rarely 1 cm long;

rachis hirsute; bracts subsessile, peltate, disk glabrous above and on the margins, transversely elliptic, 1.75 to 2.1 mm long, 1.25 to 1.75 mm wide; fruits pedicellate, ovoid-globose, 5 to 7 mm long, 4 to 4.5 mm in diameter, glabrous, black when dry, the pedicels glabrous, up to 5 mm in length; stigmas 3 or 4, ovoid, sessile, apical.

LUZON, Abra Province, Mount Posuey, *Bur. Sci. 27006 Ramos:* Benguet Subprovince, Sablan, *Elmer 6150* (type of *Piper caninum* Blume var. *sablanum* C. DC. in herb. Manila): Pampanga Province, Mount Pinatubo, *Clemens 17377.* In forests at medium altitudes. Endemic.

This species is in its less significant features close to *Piper sorsogonum* C. DC., but differs in its free, peltate bracts and shorter spikes, and in having leaves with long apices. It differs from *Piper caninum* Blume in its ovate leaves, larger fruits, and its larger, glabrous bracts.

60. PIPER TENUIPEDUNCULUM C. DC. Text fig. 72.

Piper tenuipedunculum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 460, Candollea 1 (1923) 224; MERR., Enum. Philip. Fl. Pl. 2 (1923) 16.

A diœcious vine; the branches villose, terete, 1.25 to 2 mm in diameter. Leaves thinly chartaceous, oblong-ovate to ovate, 12.5 to 14.5 cm long, 5.5 to 7.3 cm wide, base subequilaterally cordate, 9-plinerved, apex obscurely and acutely acuminate, sparsely hirtellous above, hirsute beneath, reticulations somewhat prominent on both surfaces; petioles densely hirsute, 1.5 to 2.7 cm long. Pistillate spikes pendulous, about 6 cm long, 1 to 1.2 cm in diameter; the peduncles long and slender, sparsely hirsute, about 5 cm long; rachis slender, hirsute; bracts sessile, peltate, disk membranaceous, glabrous above and on the margins, obovate, 0.75 to 1 mm wide; fruits pedicellate, remote, elliptic-oblong to oblong, about 3 mm long, 2 mm in diameter, rounded, glabrous, the pedicels up to 2 mm long; stigmas 3 or 4, linear, acute, sessile, apical.

MINDANAO, Zamboanga Province, San Ramon, *Williams 2343* [8] p. p. (type in herb. Manila), in forests, altitude about 100 meters. Endemic.

This species resembles *Piper haenkeanum* Opiz in its vegetative characters, but differs conspicuously in its long and slender peduncles, reaching a length of 5 cm.

[8] This number is in part *Piper haenkeanum* Opiz.

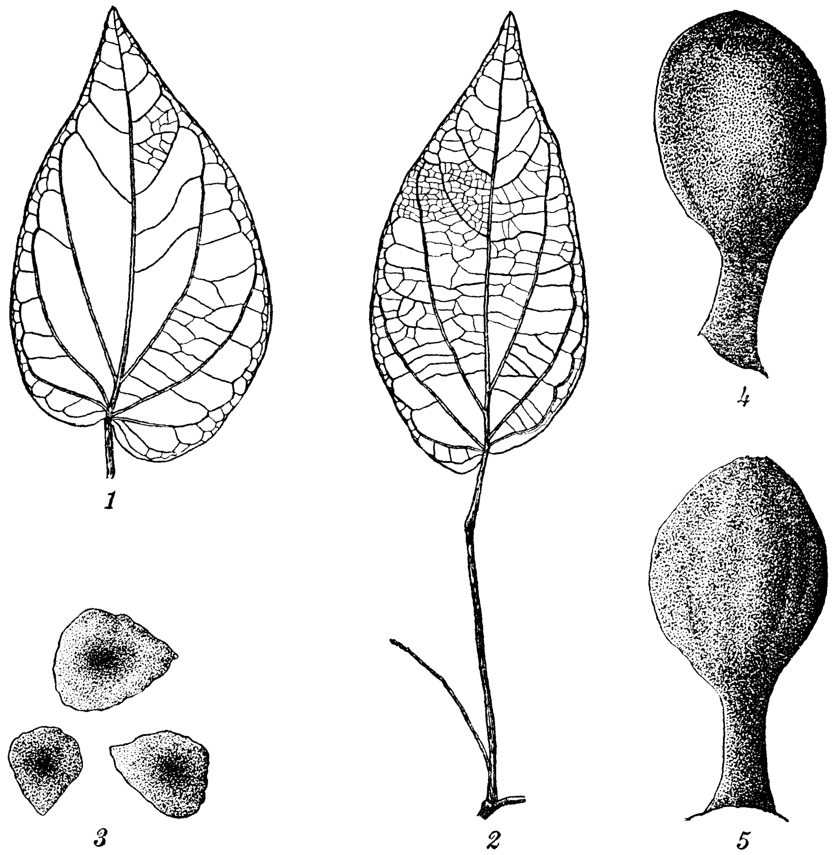


FIG. 72. *Piper tenuipedunculum* C. DC.; *1*, leaf, × 0.5; *2*, apical portion of branch, showing leaf and peduncle, × 0.5; *3*, top view of pistillate bracts, × 10; *4–5*, fruits, × 7.5.

61. PIPER MALALAGANUM C. DC. Text fig. 73.

Piper malalaganum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 461, Candollea 1 (1923) 227; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

A diœcious vine; the branches densely hirsute, terete, 1.5 to 3 mm in diameter. Leaves thinly chartaceous, oblong-elliptic to oblong-ovate, 8.5 to 12 cm long, 3.7 to 6 cm wide, base subequilaterally acute to obtuse, 7- to 9-plinerved, apex subacutely acuminate, sparsely hirsute above, densely hirsute beneath, reticulations somewhat prominent beneath; petioles densely hirsute, 11 to 13 mm long, in the lower leaves up to 20 mm in length. Pistillate spikes suberect, about 10.5 cm long, 1.5 cm in diameter; the peduncles sparsely hirsute, about 2 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous above and on the margins,

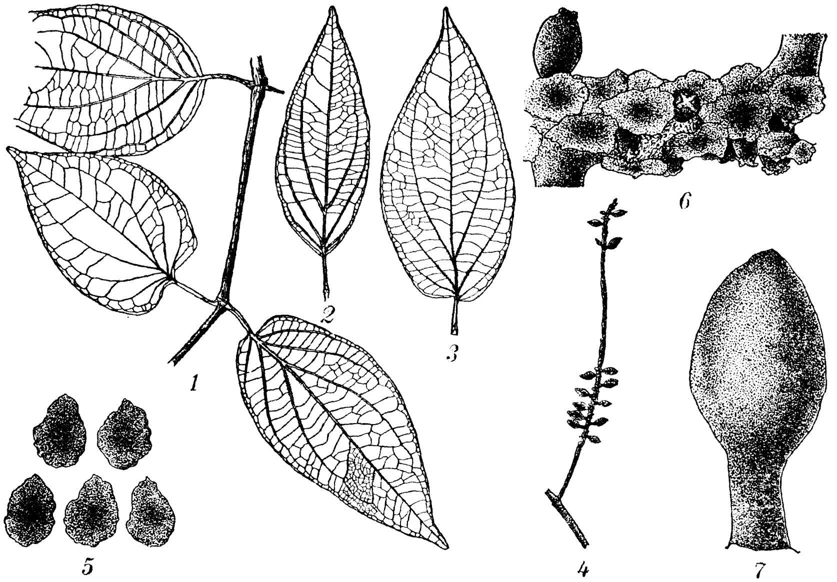


FIG. 73. *Piper malalaganum* C. DC.; *1*, branch, × 0.3; *2–3*, leaves, × 0.3; *4*, pistillate spike, × 0.3; *5*, top view of pistillate bracts, × 5; *6*, portion of pistillate spike, × 5; *7*, fruit, × 5.

membranaceous, oblong-ovate 1.25 to 1.5 mm wide; fruits pedicellate, somewhat remote, ellipsoid, 5 to 6.5 mm long, 3 to 3.5 mm in diameter, glabrous, dark brown, the pedicels glabrous, up to 3 mm in length; stigmas 4, ovoid, sessile, apical.

MINDANAO, Davao Province, Malalag, *Copeland 696* (type in herb. Manila). Endemic.

This species is certainly close to *Piper haenkeanum* Opiz, from which it may be distinguished by its branches, petioles, and peduncles not densely villose and the upper surface of the leaves pubescent on the nerves only.

62. PIPER HAENKEANUM Opiz. Text fig. 74.

Piper haenkeanum OPIZ in Presl Rel. Haenk. 1 (1828) 159; C. DC. Prodr. 16[1] (1869) 377, Philip. Journ. Sci. 5 (1910) Bot. 462; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

Piper merrittii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 460, 11 (1916) Bot. 224, Candollea 1 (1923) 225; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

Piper obovatibracteum C. DC. in Leafl. Philip. Bot. 3 (1910) 784, Philip. Journ. Sci. 5 (1910) Bot. 447, 11 (1916) Bot. 221, Candollea 1 (1923) 207; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

Piper villilimbum C. DC. in Leafl. Philip. Bot. 3 (1910) 788, Philip. Journ. Sci. 5 (1910) Bot. 461, 11 (1916) Bot. 224, Candollea 1 (1923) 226; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

A diœcious vine; the branches densely villose, terete, 1.5 to 3 mm in diameter. Leaves thinly chartaceous to chartaceous, oblong-ovate, oblong-lanceolate, elliptic-ovate or ovate-lanceolate, the lower leaves heart-shaped, 8.5 to 20 cm long, 4 to 9 cm wide, in the male as short as 6 cm long, and as narrow as 1.5 cm, the lower leaves of the female attaining a width up to 12 cm, base equilaterally to inequilaterally acute, obtuse to subrounded, the lower leaves cordate, 5- to 7-plinerved, apex acutely acumi-

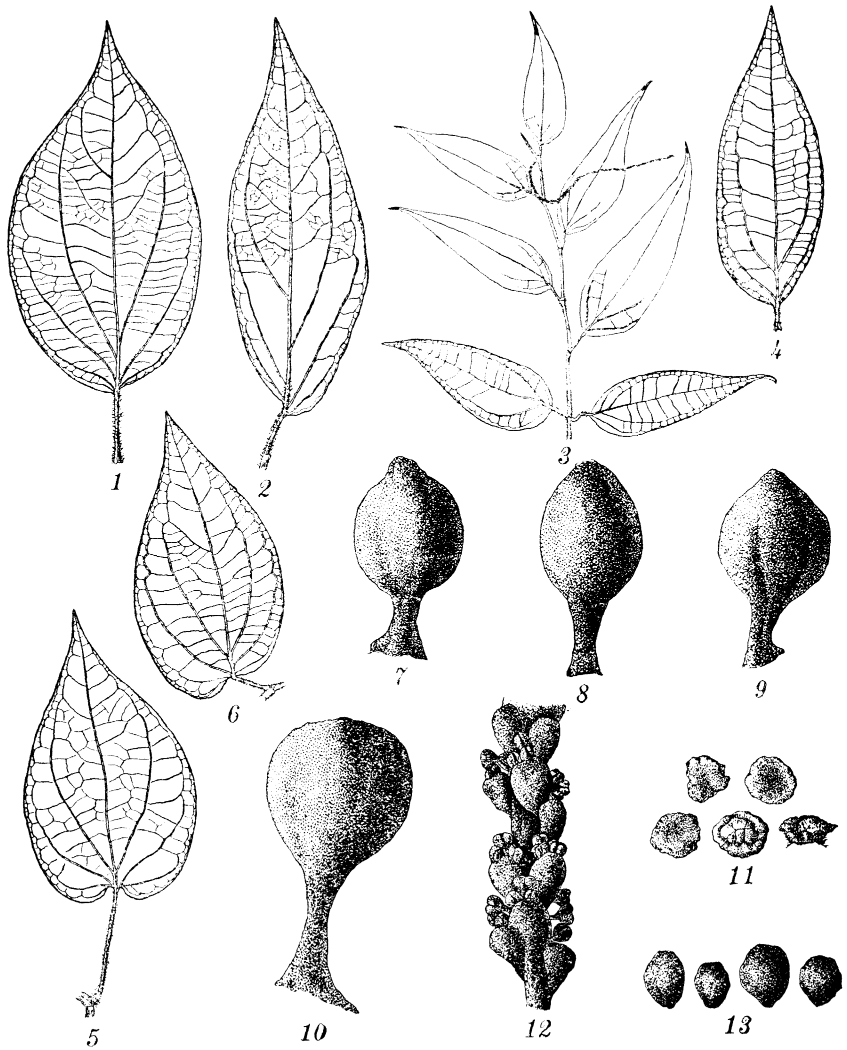


FIG. 74. *Piper haenkeanum* Opiz; *1–2*, leaves, × 0.3; *3*, branch of a male plant, × 0.3; *4*, leaf, × 0.3; *5–6*, lower leaves, × 0.3; *7–10*, fruits, × 5; *11*, top, lower, and side views of pistillate bracts, × 6.5; *12*, portion of staminate spike, × 6.5; *13*, top view of staminate bracts, × 6.5.

nate to acute, densely villose on both surfaces, margins usually villose, reticulations somewhat obscure above, more or less prominent beneath; petioles densely villose, 7 to 18 mm long, in the lower leaves up to 60 mm in length. Pistillate spikes 6 to 15.5 cm long, 1.3 to 1.8 cm in diameter; the peduncles densely villose, 1.5 to 2.5 cm long; rachis slender, hirsute, 1 to 1.5 mm in diameter; bracts sessile to subsessile, peltate, disk glabrous above and on the margins, orbicular, 0.75 to 1 mm wide; fruits pedicellate, not crowded, ovoid-globose to globose, glabrous, 3 to 4 mm long, 2.5 to 4 mm in diameter, the pedicels up to 4 mm in length; stigmas 3 or 4, ovoid, sessile, apical. Staminate spikes slender, 5.5 to 14 cm long, 1 to 1.5 mm in diameter; the peduncles densely villose, 1.3 to 2.8 cm long; rachis densely hirtellous; bracts sessile, peltate, disk glabrous above and on the margins, obovate, 0.75 to 1 mm long, 0.6 to 0.8 mm wide, apex truncate to rounded; stamens 3, rarely 2, pedicellate, about 0.5 mm long, anthers reniform, 2-valved, filaments somewhat exerted.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 20594 Ramos;* Paete, *Bur. Sci. 22828 McGregor:* Tayabas Province, Lucban, *Elmer 7624* (type collection of *Piper villilimbum* C. DC.), *7927* (type collection of *Piper obovatibracteum* C. DC.), *7382;* Tagcauayan, *Bur. Sci. 13368 Ramos;* Mount Tulaog, *Bur. Sci. 29102 Ramos and Edaño;* Casiguran, *Bur. Sci. 45417, 45475 Ramos and Edaño:* Camarines Sur Province, Mount Isarog, *Bur. Sci. 22023 Ramos:* Sorsogon Province, without definite locality, *Haenke s. n.* (type of *Piper haenkeanum* Opiz in herb. Prague); Irosin, Mount Bulusan, *Elmer 14768, 15182, 15979;* without definite locality, *Bur. Sci. 23309 Ramos;* Mount Labao, *Bur. Sci. 23544 Ramos.* CATANDUANES, Bacon, *For. Bur. 29866 Denaga.* POLILLO, *Bur. Sci. 6853 Robinson.* MINDORO, Balete, *For. Bur. 6138 Merritt* (type of *Piper merrittii* C. DC. in herb. Manila); Baco River, *Merrill 1783;* Mount Halcon, *Bur. Sci. 40677 Ramos and Edaño;* Naujan, *Bur. Sci. 46435 Ramos.* SAMAR, Cauayan Valley, *Bur. Sci. 17557 Ramos.* LEYTE, Dagami, *Wenzel 308, 327, 414, 427;* Tacloban, *Wenzel 1660, 1734, 1791;* Jaro, Buenavista, *Wenzel 916, 730.* PANAY, Capiz Province, Jamindan, *Bur. Sci. 30850, 31260 Ramos and Edaño;* Libacao, *Bur. Sci. 31433 Ramos and Edaño;* Galecia, *Bur. Sci. 35304, 35508, 35512 Martelino and Edaño;* Mount Kinablangan, *Bur. Sci. 46004, 46009 Edaño.* BOHOL, Kalingohan, *Bur. Sci. 42798 Ramos;* Bilar, *Bur. Sci. 42751 Ramos.* MINDANAO, Surigao Province, Pla-

cer, *Wenzel 1879:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13605;* Talacogon, Agusan River, *Merrill 7316:* Bukidnon Province, Tangkulan, *Bur. Sci. 39154 Ramos and Edaño.* SIARGAO, Dapa, *Bur. Sci. 34997 Ramos and Pascasio.* CAMIGUIN DE MINDANAO, Mambajao, *Elmer 14335;* Mount Volcan, *Bur. Sci. 14471, 14472 Ramos;* Mount Mahilog, *Bur. Sci. 14646 Ramos.* In forests at low and medium altitudes. Endemic.

Local names: Dumadingan (Lan.); litlít-kayakas (Mang.); manikatápai (Bag.); mandásai (Mbo.).

A species somewhat resembling *Piper caninum* Blume but easily distinguished by its leaves being copiously villose on both surfaces; its villose branches, petioles, and peduncles; its longer staminate spikes; and its obovate staminate bracts. *Piper merrittii* C. DC. and *Piper villilimbum* C. DC. are identical with this species. *Piper obovatibracteum* C. DC. is without question the male plant. I am certain of the identity of Opiz's species through an actual examination of the type courteously loaned by the Prague Herbarium.

63. PIPER CORDATILIMBUM sp. nov. Text fig. 75; Plate 12.

Frutex dioicus, scandens; ramulis petiolis et pedunculis dense pubescentibus; foliis chartaceis, stricte cordatis, 8 ad 14.5 cm longis, 5 ad 11 cm latis, basi aequilateralibus ad inaequilateralibus cordatis, 9-plinerviis, apice acute acuminatis, utrinque dense villosis; spicis ♀ 4 ad 7 cm longis; bracteis subsessilibus, peltatis, peltis transverse oblongis, 2 ad 2.25 mm longis, 1.5 ad 1.75 mm latis, supra marginibusque glabris; fructibus junioribus fusiformibus, vetustioribus ellipsoideis ad globosis, apice rostellatis, 4 ad 6 mm longis, 3 ad 4 mm diametro.

A diœcious vine; the branches densely villose, terete, 2 to 5 mm in diameter. Leaves thinly chartaceous to chartaceous, upper and lower broadly heart-shaped, 8 to 14.5 cm long, 5 to 11 cm wide, base equilaterally to inequilaterally cordate, lobes rounded, sinuses up to 23 mm deep, 9-plinerved, rarely subplinerved, apex acutely acuminate, densely villose on both surfaces, margins densely villose; petioles densely villose, 1.5 to 3.5 cm long, in the lower leaves up to 5.5 cm in length. Pistillate spikes pendulous, 4 to 7 cm long, about 1.5 cm in diameter; the peduncles densely villose, 10 to 30 mm long; rachis densely villose, 2 to 3 mm in diameter; bracts subsessile, peltate, disk fleshy, glabrous above and on the margins, transversely oblong, 2 to 2.25 mm long, 1.5 to 1.75 mm wide; fruits pedicellate, not crowded, submature fusiform, mature ones ellipsoid to globose,

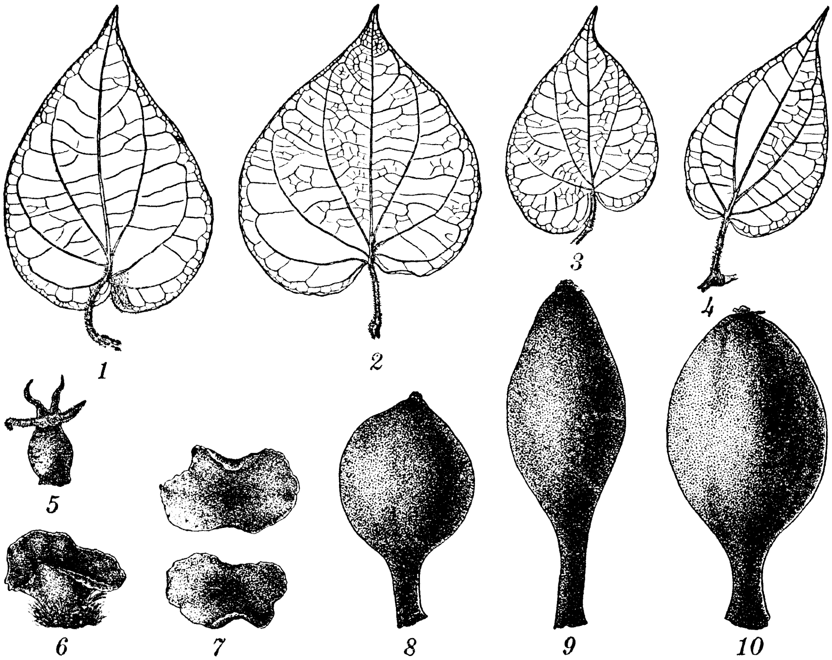


FIG. 75. *Piper cordatilimbum* sp. nov.; *1–4*, leaves, × 0.3; *5*, ovary, × 6.5; *6*, side view of pistillate bract, × 6.5; *7*, top view of pistillate bracts, × 6.5; *8–10*, fruits, × 5.

4 to 6 mm long, 3 to 4 mm in diameter, apex rostellate, acute, glabrous, the pedicels up to 3 mm long; stigmas usually 4, rarely 3 or 5, linear, acute, sessile, apical.

LUZON, Laguna Province, San Antonio, *Baker 2452, Bur. Sci. 16537 Ramos;* without definite locality, *Bur. Sci. 24933 Ramos:* Tayabas Province, Lucban, *Elmer 7627.* CATANDUANES, Mount Mareguidoy, *Bur. Sci. 30431 Ramos and Chan.* LEYTE, Jaro, Buenavista, *Wenzel 1095* (type collection of *Piper merrittii* C. DC. var. *parvifolium* C. DC.), *502, 1173;* Dagami, *Wenzel 309.* BOHOL, Bilar, *Bur. Sci. 42699 Ramos* (type in herb. Manila). MINDANAO, Davao Province, Todaya, Mount Apo, *Elmer 10581;* Mount Mayo, *Bur. Sci. 49482 Ramos and Edaño.* In forests at low and medium altitudes, ascending to 1,200 meters.

Two of the plants cited here were originally described by C. de Candolle as a form and variety of *Piper merrittii* C. DC. Further studies and an examination of more abundant material have convinced me that these plants do not belong to *Piper merrittii* C. DC. The proposed new species stands near to *Piper caninum* Blume var. *latibracteum* C. DC., from which it may be

readily distinguished by its strictly and broadly heart-shaped leaves, its transversely oblong bracts, and its rostellate fruits.

64. PIPER CABADBARANUM C. DC. Text fig. 76.

Piper cabadbaranum C. DC. in Leafl. Philip. Bot. 6 (1914) 2292, Candollea 1 (1923) 221; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

A diœcious vine; the branches glabrous, terete, 1 to 2 mm in diameter. Leaves firm, subcoriaceous, elliptic-ovate to elliptic-ovate-lanceolate, 6 to 9.3 cm long, 2 to 4.2 cm wide, base equilaterally to subequilaterally acute, 5-plinerved, apex acutely acuminate, glabrous on both surfaces, shining above, reticulations prominent on both surfaces; petioles glabrous, 8 to 20 mm long, in the lower leaves up to 30 mm long. Pistillate spikes usually retrose, 2.5 to 3.5 cm long, about 1.5 cm in diameter; the peduncles glabrous, 1.5 to 2 cm long; rachis hirsute; bracts sessile, peltate, disk orbicular-obovate to orbicular, 0.75 to 1 mm wide, ciliate above and on the margins, fleshy; fruits somewhat crowded, pedicellate, obovoid to globose, 4 to 4.5 mm long, 2.5 to 3 mm in diameter, glabrous, glandular, the pedicels sparingly glandular, up to 4 mm in length; stigmas 3 or 4, ovoid, obtuse, sessile, apical.

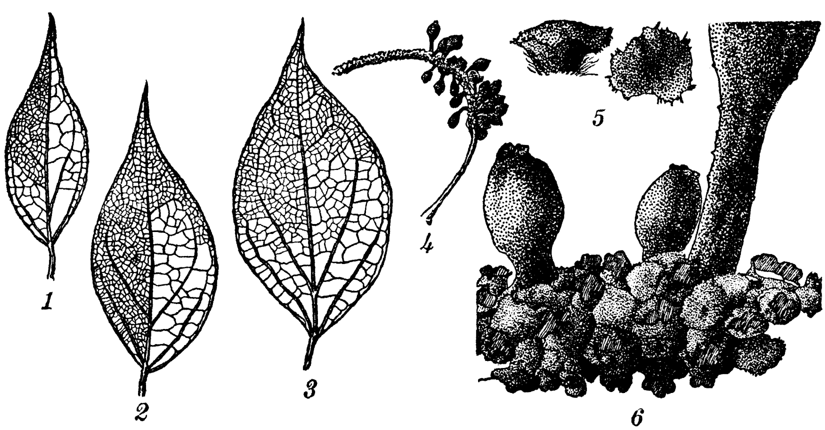


FIG. 76. *Piper cabadbaranum* C. DC.; *1–3*, leaves, × 0.5; *4*, pistillate spike, × 0.5; *5*, side and top views of pistillate bracts, × 10; *6*, portion of pistillate spike, × 7.5.

CATANDUANES, Santo Domingo, *Bur. Sci. 30536 Ramos and Chan.* MINDANAO, Agusan Province, Mount Urdaneta, *Elmer 14136* (type collection). Endemic.

A species allied to *Piper caninum* Blume, differing in its entirely glabrous branches, petioles, and peduncles, its glabrous,

subcoriaceous, elliptic-ovate to elliptic-ovate-lanceolate leaves, and its glandular fruits.

65. PIPER LONGIPEDICELLATUM sp. nov. Text fig. 77; Plate 13.

Frutex dioicus, scandens; ramulis 1.5 ad 2.5 mm diametro; foliis chartaceis, ovatis, 5 ad 8 cm longis, 3 ad 5 cm latis, basi aequilateralibus ad subaequilateralibus acutis, 5- ad 7-plinerviis, apice acute acuminatis, supra glabris, subtus hirtellis; spicis ♀ 4 ad 4.5 cm longis; bracteis sessilibus, peltatis, peltis subor-

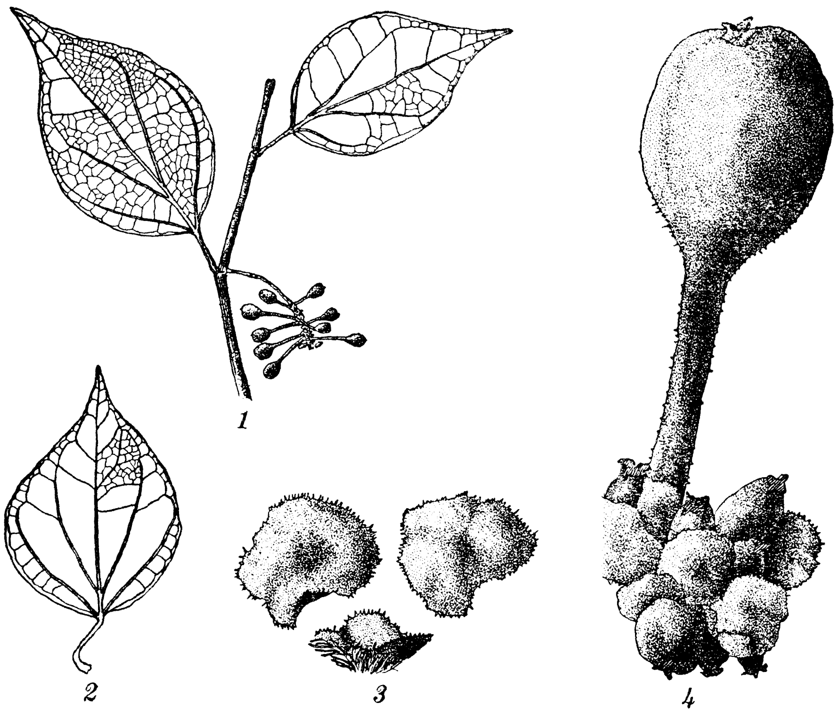


FIG. 77. *Piper longipedicellatum* sp. nov.; *1*, fruiting branch with lower portion of pistillate spike, × 0.5; *2*, lower leaf, × 0.5; *3*, top and side views of pistillate bracts, × 10; *4*, portion of pistillate spike, × 7.5.

bicularis, ad 1.5 mm latis, supra glabris, margine ciliatis; fructibus longe pedicellatis, subglobosis, 4 ad 5 mm longis, 3.5 ad 4 mm diametro, basi parce hirtellis, pedicellis usque ad 9 mm longis.

A diœcious vine; the branches terete, hirtellous, 1.5 to 2.5 mm in diameter. Leaves chartaceous, ovate, 5 to 8 cm long, 3 to 5 cm wide, the lower ones about 9 cm long, 7 cm wide, base equilaterally to subequilaterally acute, 5- to 7-plinerved, apex acutely acuminate, glabrous and shining above, sparsely hirtel-

lous to hirtellous beneath, reticulations more or less prominent on both surfaces; petioles hirtellous, 10 to 15 mm long, in the lower leaves up to 20 mm long. Pistillate spikes retrorse, 4 to 4.5 cm long, 1.8 to 2.3 cm in diameter; the peduncles hirtellous, 1.5 to 2 cm long; rachis hirsute; bracts sessile, peltate, disk glabrous above, ciliate on the margins, membranaceous, suborbicular, 1 to 1.5 mm wide; fruits long-pedicellate, spreading at maturity, subglobose, 4 to 5 mm long, 3.5 to 4 mm in diameter, sparsely hirtellous at their bases, the pedicels sparsely hirtellous, up to 9 mm long; stigmas 3 or 4, ovoid, acute, sessile, apical.

LUZON, Bontoc Subprovince, Mount Caua, *Bur. Sci. 38066 Ramos and Edaño* (type in herb. Manila), March 3,1920, on slopes in the mossy forest, altitude about 1,800 meters: Ifugao Subprovince, Mount Polis, *Bur. Sci. 19820 McGregor*, February 6, 1913.

This species is allied to *Piper cabadbaranum* C. DC., but may be readily distinguished by its long-pedicellate fruits, the pedicels pubescent at their bases. In vegetative character *Piper cabadbaranum* C. DC. is suggested, but the present species is distinguished by its pubescent leaves, petioles, branches, and peduncles.

66. PIPER ARBORISEDENS C. DC. Text fig. 78.

Piper arborisedens C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 223, Candollea 1 (1923) 223; MERR., Enum. Philip. Fl. Pl. 2 (1923) 3.

A diœcious vine; the branches glabrous, terete, black, 1.5 to 3 mm in diameter. Leaves chartaceous, lanceolate, 8 to 11 cm long, 2 to 3.5 cm wide, base equilaterally to subequilaterally acute, 5-plinerved, narrowed to the slenderly acuminate apex, entirely glabrous on both surfaces, reticulations somewhat obscure to obsolete beneath; petioles glabrous, 10 to 18 mm long, in the lower leaves up to 30 cm long. Pistillate spikes subpendulous, 3 to 4 cm long, 1.5 to 2 cm in diameter; the peduncles glabrous, about 1.5 cm long; rachis hirsute; bracts sessile, peltate, disk fleshy, glabrous above and on the margins, suborbicular to orbicular, 1 to 1.25 mm wide, margin somewhat undulate; fruits pedicellate, somewhat crowded, fusiform, umbonate, 5 to 6.5 cm long, 3 to 4 mm in diameter, glabrous, black when dry, the pedicels glabrous, up to 3 mm in length; stigmas 3, ovoid, acute, sessile, apical.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 24934 Ramos* (type collection), August 20, 1910, in forests. Endemic.

A species belonging in the group with *Piper caninum* Blume by its pedicellate fruits and resembling *Piper spathelliferum*

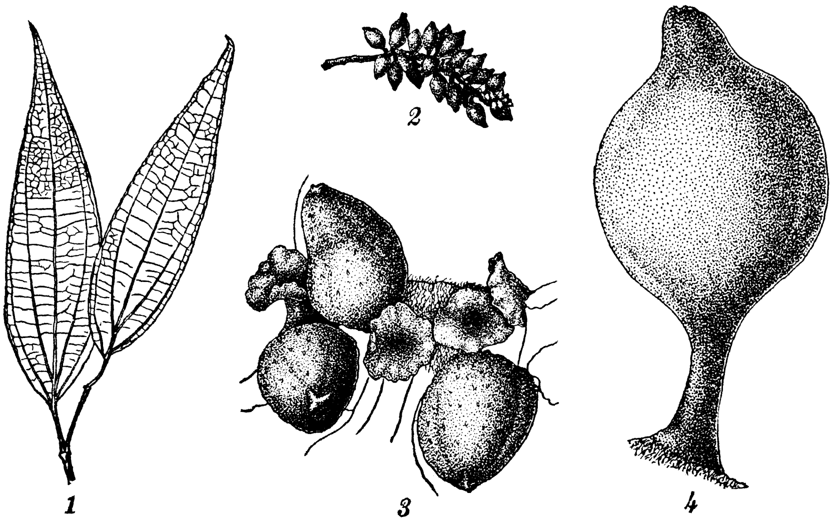


FIG. 78. *Piper arborisedens* C. DC.; *1*, leaves, × 0.5; *2*, pistillate spike, × 0.5; *3*, portion of pistillate spike, × 7.5; *4*, fruit, × 7.5.

sp. nov. in leaf form and texture, but differing from the latter in many respects, in its plinerved lamina, fusiform, pedicellate fruits and sessile, peltate bracts. It is distinguished from *Piper caninum* Blume by the form, texture, and color of its leaves and by its glabrous bracts.

67. PIPER ACUTIBACCUM C. DC. Text fig. 79.

Piper acutibaccum C. DC. in Philip. Journn. Sci. 5 (1910) Bot. 459, Candollea 1 (1923) 225; MERR., Enum. Philip. Fl. Pl. 2 (1923) 2.

A diœcious vine; the branches pilose, terete, 1.25 to 2.5 mm in diameter. Leaves chartaceous, elliptic-lanceolate, 10.5 to 14.5 cm long, 3 to 4.5 cm wide, base equilateral, cuneate, 5-plinerved, narrowed to the slenderly acuminate apex, entirely glabrous above, sparsely pilose beneath, olivaceous above when dry, paler beneath, reticulations more or less obscure beneath; petioles pilose, 10 to 12 mm long, in the lower leaves up to 20 mm in length. Pistillate spikes suberect, 4 to 7 cm long, 1.5 to 1.8 cm in diameter; the peduncles sparsely pilose, 10 to 15 mm long; rachis hirsute; bracts subsessile, peltate, disk glabrous above and on the margins, suborbicular to orbicular, 1 to 1.5 mm wide; fruits pedicellate, more or less crowded, fusiform, 7 to 8.5 cm long, 2.75 to 3.5 mm in diameter, glabrous, black when dry, the pedicels glabrous, up to 3 mm in length; stigmas 3, linear, sessile, apical.

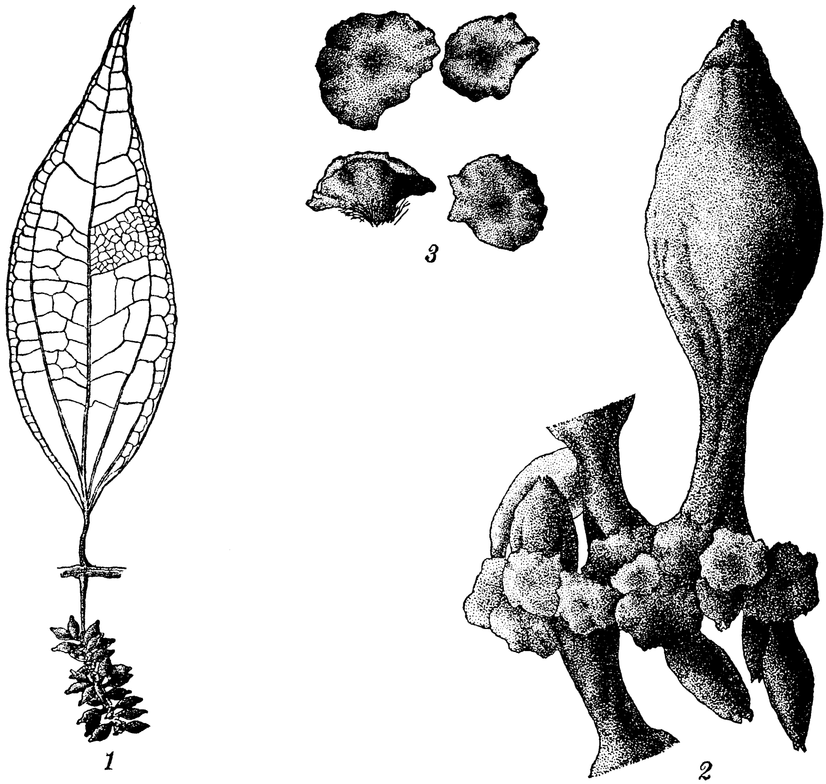


FIG. 79. *Piper acutibaccum* C. DC.; *1*, typical leaf and lower portion of pistillate spike, × 0.5; *2*, portion of pistillate spike, × 7.5; *3*, top and side views of pistillate bracts, × 10.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 10031 Ramos* (type in herb. Manila), in forests at low altitudes. Endemic.

This species, belonging in the group with *Piper caninum* Blume, stands very near *Piper arborisedens* C. DC., but differs from the latter conspicuously in its pubescent leaves, branches, petioles, and peduncles and in its subsessile bracts.

68. PIPER PAUCINERVE C. DC. Text fig. 80; Plate 14.

Piper paucinerve C. DC. in Perk. Frag. Fl. Philip. (1905) 156, Philip. Journ. Sci. 5 (1910) Bot. 456, Candollea 1 (1923) 222, 227; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branches glabrous, terete, 1 to 1.5 mm in diameter. Leaves subchartaceous, elliptic-lanceolate, 8.5 to 10.5 cm long, 2.2 to 3.5 cm wide, base equilaterally acute, 5-plinerved, apex acutely acuminate, entirely glabrous on both surfaces, reticulations somewhat prominent on both surfaces; petioles gla-

brous, 7 to 15 mm long. Pistillate spikes subpendulous, 2 to 3.3 cm long, about 1.5 cm in diameter; the peduncles glabrous, 12 to 13 mm long; rachis densely hirtellous; bracts sessile, peltate, disk glabrous above and on the margins, membranaceous, transversely elliptic, about 1 mm wide; ovaries minutely puberulent; fruits pedicellate, not crowded, ellipsoid, about 4 mm long, 3 mm in diameter, glabrous, the pedicels glabrous, up to 2 mm long; stigmas 3, ovoid, acute, sessile, apical.

LUZON, Isabela Province, Malunu, *Warburg 11929* (type in herb. Berlin). Endemic.

A species in some respects resembling *Piper arborisedens* C. DC., but differing in its transversely elliptic bracts, its minutely puberulent ovaries, and its ellipsoid fruits.

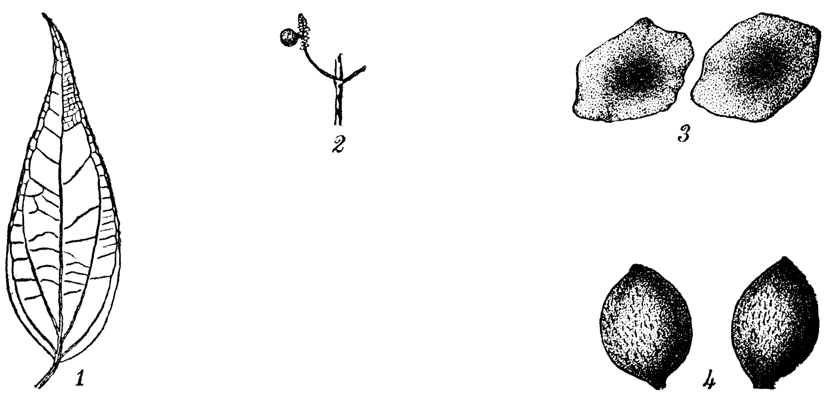


FIG. 80. *Piper paucinerve* C. DC.; *1*, typical leaf, × 0.5; *2*, portion of the pistillate spike, × 0.5; *3*, top view of pistillate bracts, × 7.5; *4*, fruits, × 7.5.

69. PIPER BREVISTIGMUM C. DC. Text fig. 81.

Piper brevistigmum C. DC. in Leafl. Philip. Bot. **6** (1914) 2292, Candollea **1** (1923) 203; MERR., Enum. Philip. Fl. Pl. **2** (1923) 5.

A diœcious vine; the branches glabrous, terete, smooth, 1.5 to 3 mm in diameter. Leaves chartaceous, brown, ovate to broadly ovate, 7 to 12 cm long, 4.5 to 10 cm wide, base usually oblique, subequilaterally obtuse to subrounded, 5-plinerved, apex acutely acuminate, glabrous above, more or less pilose on the nerves and sparingly so on the parenchyma beneath, reticulations more or less prominent beneath; petioles glabrous, 10 to 15 mm long, in the lower leaves up to 30 mm in length. Pistillate spikes pendulous, interrupted, 5.5 to 7.5 cm long, 9 to 10 mm in diameter; the peduncles glabrous, 1 to 1.8 cm long; rachis hirsute; bracts free, sessile, peltate, disk glabrous above, ciliate on

the margins, subrounded to rounded-subobovate, 1.25 to 1.5 mm wide; fruits free, sessile, oblong-obovoid, 4 to 4.5 mm long, 2.5 to 3 mm in diameter, glabrous; stigmas 3, ovoid, acute, sessile, apical.

MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13684* (type collection), in forests, altitude about 1,000 meters. Endemic.

Local name: Ianahon (Mbo.).

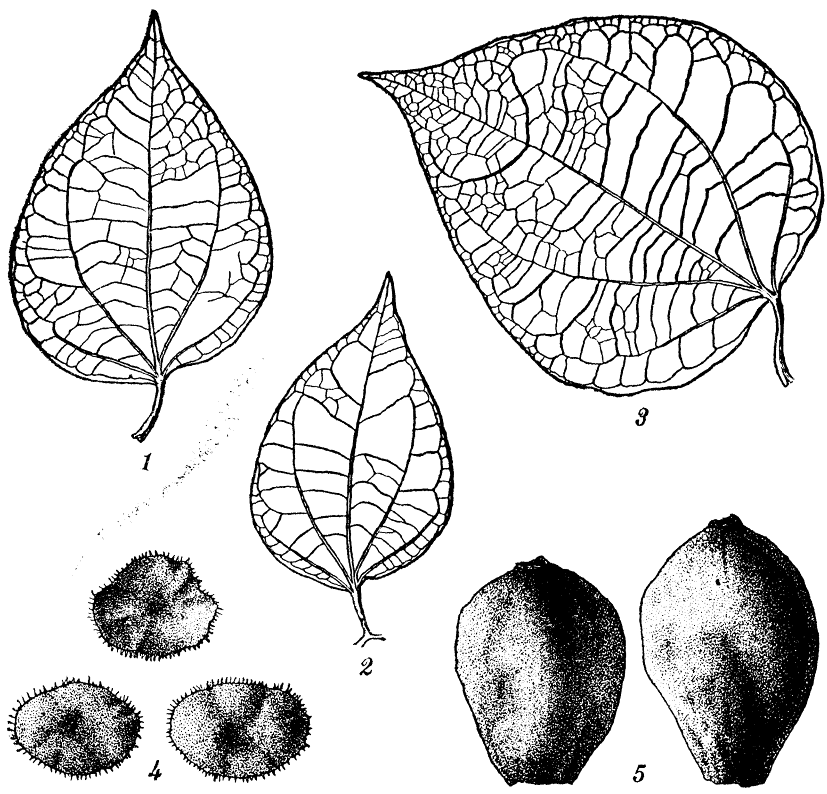


FIG. 81. *Piper brevistigmum* C. DC.; *1–3*, leaves, × 0.5; *4*, top view of pistillate bracts, × 10; *5*, fruits, × 7.5.

According to C. de Candolle the species is close to the Javanese *Piper cilibracteum* C. DC., which I have not seen. It is probably intermediate between *Piper caninum* Blume and *Piper interruptum* Opiz. It is related to *Piper caninum* Blume by its sessile, peltate bracts, but differs in its sessile fruits. In the latter character it appears near to *Piper interruptum* Opiz. It has ovate to broadly ovate leaves and ciliate bracts.

70. **PIPER SORSOGONUM** C. DC. Text fig. 82.

Piper sorsogonum C. DC. in Candollea 1 (1923) 223, *nomen nudum*, 2 (1923) 188.

Dioicus, scandens; foliis chartaceis, ovatis ad rotundato-ovatis, 10 ad 17 cm longis, 6.5 ad 10.5 cm latis, foliis ad basi usque ad

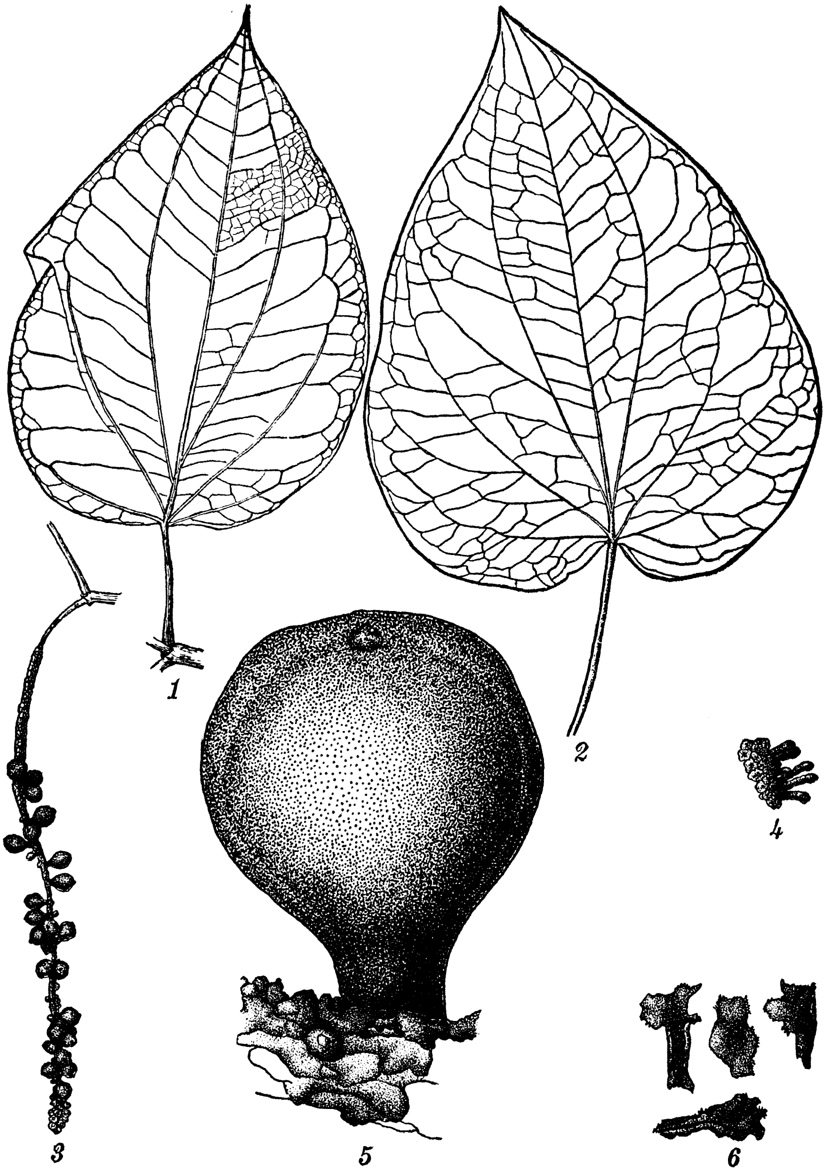


FIG. 82. *Piper sorsogonum* C. DC.; *1–2*, leaves, × 0.5; *3*, pistillate spike, × 0.5; *4*, hairs on the bracts, much enlarged; *5*, fruit and portion of the rachis, × 7.5; *6*, top and side views of pistillate bracts, × 7.5.

20.5 cm longis, 19.5 cm latis, base aequilateralibus ad subaequilateralibus rotundatis vel cordatis, 7-plinerviis, apice acute acuminatis, utrinque glabris; petiolo glabro, 2 ad 4.5 cm longo; spicis ♀ 9.5 ad 19.5 cm longis; pedunculis glabris; rachis puberulis; bracteis adnatis cum rachis, apice marginibusque liberis, ciliatis, oblongis, 1.5 ad 2 mm longis, 0.5 ad 1 mm latis; fructibus pedicellatis, glabris, ellipsoideis ad subglobosis, 4 ad 6.5 mm longis, 3 ad 5 mm diametro, pedicellis usque ad 5 mm longis, glabris; stigmatibus 3 vel 5, ovoideis, acutis, sessilibus.

A diœcious vine; the branches glabrous, terete, 2 to 5 mm in diameter. Leaves chartaceous, ovate to rounded-ovate, 10 to 17 cm long, 6.5 to 10.5 cm wide, the lower ones up to 20.5 cm long, 19.5 cm wide, base equilaterally to subequilaterally rounded or cordate, 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations more or less prominent beneath; petioles glabrous, rugose, 2 to 4.5 cm long, in the lower ones up to 6.5 cm in length. Pistillate spikes long, pendulous, 9.5 to 19.5 cm long, 1.5 to 2 cm in diameter; the peduncles glabrous, 1.8 to 2.5 cm long; rachis puberulent; bracts adnate to the rachis, apex and margin free, oblong, with the apex wider than the base, 1.5 to 2 mm long, 0.5 to 1 mm wide, ciliate above and on the margins; fruits pedicellate, glabrous, ellipsoid to subglobose, 4 to 6.5 mm long, 3 to 5 mm in diameter, black when dry, pedicels up to 5 mm in length, glabrous; stigmas 3 or 5, ovoid, acute, sessile, apical.

LUZON, Camarines Norte Province, Mount Bacacay, *Bur. Sci. 33835 Ramos and Edaño:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 14921* (type collection). LEYTE, Mount Abucayan, *Bur. Sci. 41833 Edaño.* In forests at low and medium altitudes. Endemic.

This species is allied to *Piper elmeri* Merr. by its pedicellate fruits and the nature of its bracts, but differs in its smaller and glabrous leaves and its relatively smaller fruits and bracts.

71. PIPER ELMERI Merr. Text figs. 83 and 84.

Piper elmeri MERR. in Philip. Journ. Sci. 17 (1920) 245, Enum. Philip. Fl. Pl. 2 (1923) 8.

A coarse, woody, diœcious vine; the branches glabrous, terete, the older ones rugose, brownish when dry, about 1 cm in diameter. Leaves chartaceous to subcoriaceous, broadly ovate, 15 to 28 cm long, 11 to 23 cm wide, base equilateral to subequilateral, deeply cordate, the lobes broadly rounded, the sinuses up to 4 cm deep, 10- to 12-plinerved, apex shortly and acutely acu-

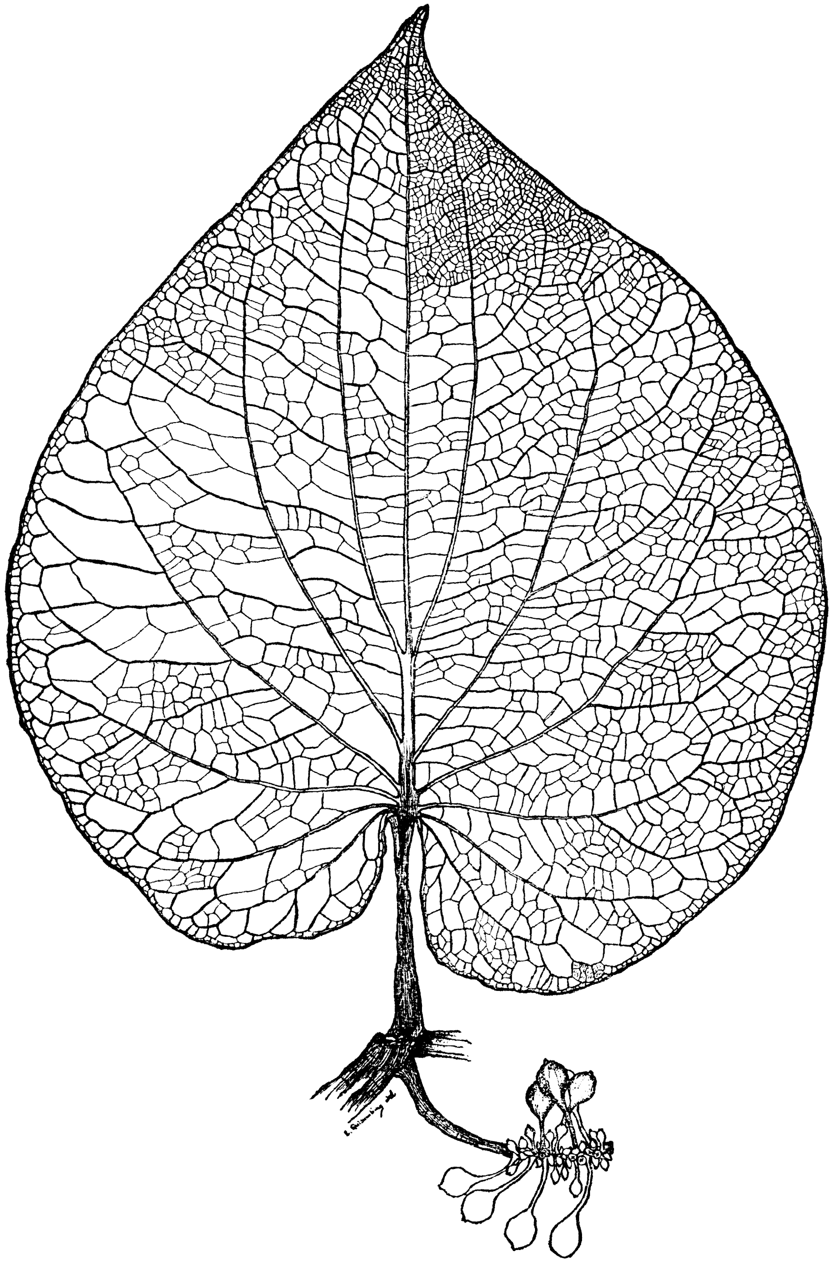


FIG. 83. *Piper elmeri* Merr.: typical leaf of the female plant with portion of the pistillate spike, × 0.5.

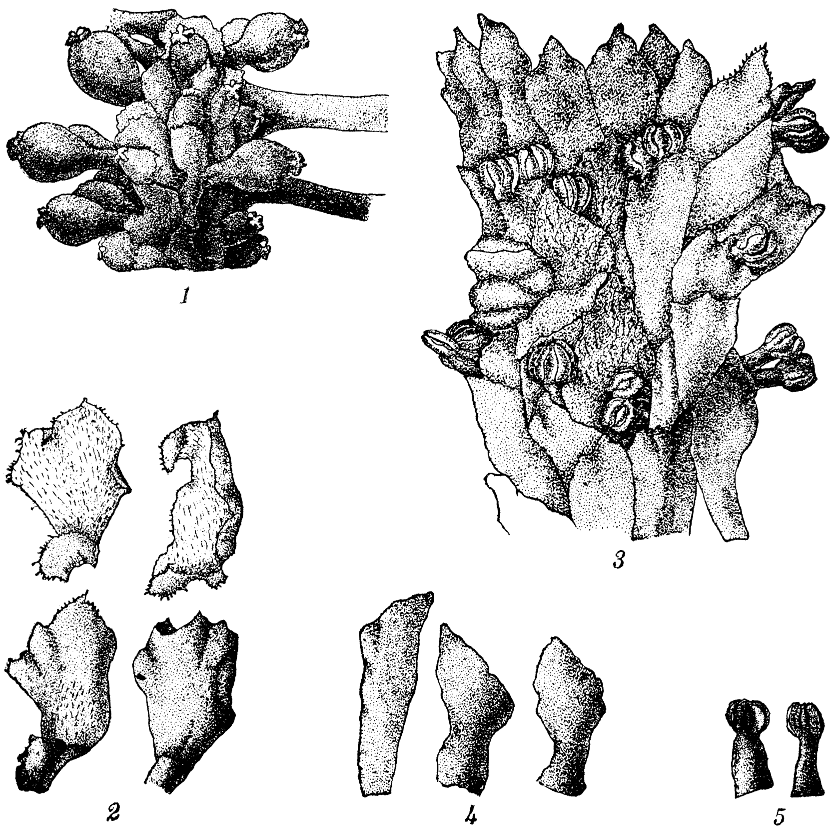


FIG. 84. *Piper elmeri* Merr.; *1*, portion of pistillate spike, × 7.5; *2*, top and side views of pistillate bracts, × 7.5; *3*, portion of staminate spike, × 7.5; *4*, top view of staminate bracts, × 7.5; *5*, stamens, × 7.5.

minate, quite glabrous, shining and olivaceous above, densely and softly pubescent beneath, reticulations prominent on both surfaces; petioles sparsely to densely hirsute, rugose, 4 to 6.5 cm long. Pistillate spikes long, pendulous, 20 to 23 cm long, 3.5 to 5 cm in diameter; the peduncles glabrous, rugose, 2.5 to 3.5 cm long; rachis densely pilose, rather stout, about 5 mm in diameter; bracts adnate to the rachis, apex and margins free, oblong-obovate, acute, 3 to 4 mm long, 1.5 to 2.5 mm wide at the apex, ciliate above and on the margins, fleshy; fruits large, spreading, pedicellate, ovoid-globose, 7 to 9 mm long, 6.5 to 8 mm in diameter, apex umbonate, yellowish red when fresh, somewhat wrinkled and usually black when dry, glabrous, pedicels hirtellous at their bases, up to 1.5 cm long; stigmas 3 or 5, ses-

sile, apical. Staminate spikes long, pendulous, 17 to 25 cm long, 4 to 6 mm in diameter; the peduncles hirtellous, 1.5 to 2 cm long; rachis densely pilose; bracts adnate to the rachis, apex and margins free, oblanceolate to oblong-ovate, subacute, 3 to 4 mm long, up to 1.5 mm wide at the apex, up to 1 mm wide at the base, ciliate above and on the margins, membranaceous; stamens 2, pedicellate, 1.75 to 2 mm long, anthers oblong, 2-valved, 0.5 to 0.75 mm wide, filaments cylindric, somewhat swollen at the base, longer than the anthers.

LUZON, Laguna Province, Mount Maquiling, *For. Bur. 26751 Mabesa, Elmer 18059:* Sorsogon Province, Mount Pocdol, *Bur. Sci. 23490 Ramos.* SAMAR, Catubig River, *Bur. Sci. 24256 Ramos* (type in herb. Manila). In damp forests at low and medium altitudes, ascending to 450 meters on Mount Maquiling. Endemic.

Local name: Buyog-halas (Bik.).

A remarkable species, easily recognized by its broadly ovate, deeply cordate leaves, which are softly pubescent beneath; its rather stout, elongated spikes and their pubescent bracts; and its large, long-pedicellate fruits. This species and *Piper sorsogonum* C. DC. stand in a group by themselves. They are somewhat allied to *Piper caninum* Blume by their pedicellate fruits and to *Piper interruptum* Opiz by their bracts, which are adnate to the rachis. In some of its vegetative features, the species bears resemblance to *Piper mollissimum* Blume. No critical comparison of the reproductive features is made as the isotype specimen of Blume's species in the Gray Herbarium is sterile.

72. PIPER INTERRUPTUM Opiz. Text figs. 85, 1–3; 86; Plate 17, fig. 1.

Piper interruptum OPIZ in Presl Rel. Haenk. 1 (1828) 157; MIQ., Syst. Pip. (1843) 336; C. DC., Prodr. 16¹ (1869) 377, Philip. Journ. Sci. 5 (1910) Bot. 448 (incl. forma *b* C. DC.), 11 (1916) Bot. 222 (incl. forma *c* C. DC.), Candollea 1 (1923) 216–217; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

A diœcious vine; the branches glabrous, terete, 2 to 4.5 mm in diameter. Leaves submembranaceous to chartaceous, oblong-elliptic to ovate, 6 to 13 cm long, 3.5 to 7 cm wide, base equilaterally to subequilaterally subacute to rounded, 5-nerved, rarely 7-nerved, apex acutely acuminate, glabrous on both surfaces, reticulations prominent beneath; petioles glabrous, 1 to 2.5 cm long, in the lower leaves up to 4 cm in length. Pistillate spikes pendulous, elongated, interrupted, 5 to 17.5 cm long, 0.8 to 1.5 cm in diameter; the peduncles glabrous, 1 to 4 cm long; rachis pilose; bracts long, adnate to the rachis, margins and apex free,

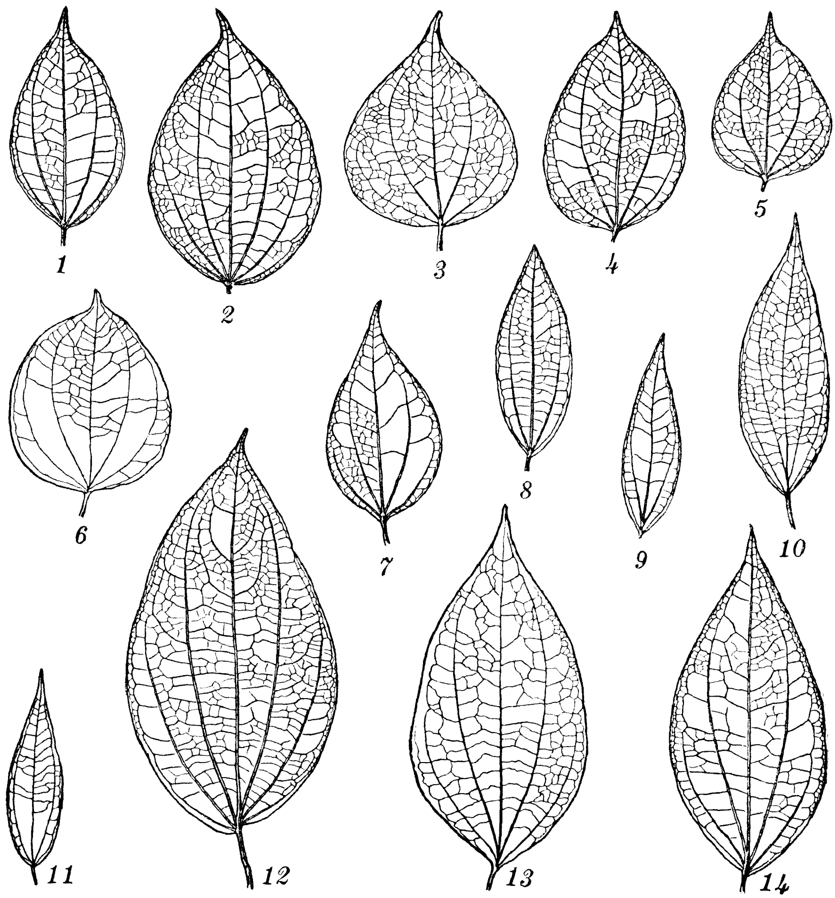


FIG. 85. Leaves of: *1–3*, *Piper interruptum* Opiz; *4–6*, var. *loheri* (C. DC.) comb. nov.; *7–11*, var. *cumingianum* (Miq.) comb. nov.; *12*, var. *laevirameum* C. DC.; *13–14*, var. *multiplinerve* C. DC. All × 0.3.

apex obtuse to repand, 2.5 to 3 mm long, 1.2 to 1.5 mm wide, glabrous; fruits free, sessile, ovoid, oblong-ovoid, or globose-ovoid, 3 to 6 mm long, 2 to 4 mm in diameter, glabrous, smooth to slightly glandular; stigmas 3 or 4, ovoid, acute, sessile, apical. Staminate spikes greatly elongated, pendulous, cylindric, 11 to 27 cm long, 1.5 to 3 mm in diameter; the peduncles glabrous, 1 to 4.5 cm long; rachis slightly pilose; bracts long, adnate to the rachis, margins and apex free, never fully imbricate, 3 to 4 mm long, 0.5 to 1 mm wide, apex obtuse to subrounded; stamens 2 or 3, two lateral and one posterior, the latter usually smaller, 0.6 to 11 mm long, anthers oblong to reniform, 2-valved, filaments oblong, as long as the anthers or slightly longer.

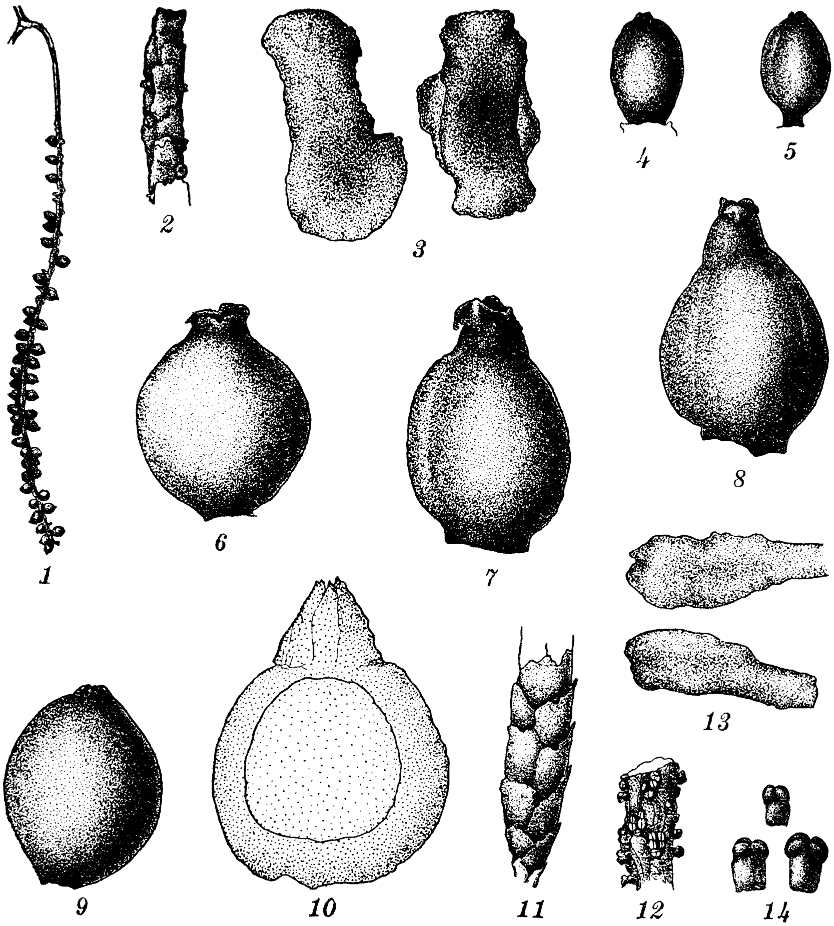


FIG. 86. *Piper interruptum* Opiz; *1*, pistillate spike, × 0.5; *2*, bracts and ovaries on young pistillate spike, × 1.5; *3*, top view of pistillate bracts, × 7.5; *4–5*, fruits, × 2.5; *6–9*, fruits, × 7.5; *10*, longitudinal section of a fruit, × 10; *11*, bracts on the staminate spike, × 3; *12*, portion of staminate spike, enlarged; *13*, top view of staminate bracts, × 7.5; *14*, stamens, × 7.5.

LUZON, without definite province or locality, *Haenke s. n.* 1792 (type of *Piper interruptum* Opiz in herb. Prague): Cagayan Province, Abulug to Linao, *For. Bur. 11611 Curran:* Bontoc Subprovince, Mount Malaya, *Bona 426:* Nueva Viscaya Province, Campote, *Bur. Sci. 20144 McGregor:* Nueva Ecija Province, Bongalon, *For. Bur. 8495 Curran:* Bulacan Province, Angat, *Philip. Pl. 1435 Ramos:* Bataan Province, Lamao, Mount Mariveles, *Williams 16:* Rizal Province, Montalban, *Philip. Pl. 269 Merrill;*

Pasig, *Bur. Sci. 11840 Robinson:* Laguna Province, Los Baños, *Hallier s. n.* 1903, *Baker 1764;* Calauan, *Bur. Sci. 12421, 12425 McGregor;* Lilio, *Bur. Sci. 6015 Robinson:* Tayabas Province, *Bur. Sci. 45340 Ramos and Edaño:* Batangas Province, *Milaor 278.* In forests at low and medium altitudes. The species, including the varieties, is widely distributed in the Philippines, and occurs also in New Guinea.

Local names: Ikmong-uák (Tag.); litlít (Tag.); paminta (Tag.).

A species strongly characterized by its elongated, interrupted pistillate spikes, its long bracts which are adnate to the rachis, and its exerted stamens.

Var. LOHERI (C. DC.) comb. nov. Text fig. 85, 4-6.

Piper loheri C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 450, 11 (1916) Bot. 223, Candollea 1 (1923) 216; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Piper abraense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 451, Candollea 1 (1923) 217; MERR., Enum. Philip. Fl. Pl. 2 (1923) 2.

Leaves elliptic-ovate to rounded-ovate, 6 to 10.5 cm long, 2.8 to 7.5 cm wide, base equilaterally to subequilaterally acute to rounded, 5-nerved, apex acutely acuminate.

LUZON, without definite province and locality (northern Luzon), *Warburg 12123:* Abra Province, Baret, *Bur. Sci. 7195 Ramos* (type of *Piper abraense* C. DC. in herb. Manila): La Union Province, Bauang, *Bur. Sci. 12983 Fénix* (type collection of *Piper loheri* C. DC. forma *c* C. DC.), *Elmer 5738;* San Fernando, *Lete 66:* Pangasinan Province, Libtong, Villasis, *Alberto 45:* Pampanga Province, Arayat, *Villegas 20:* Bulacan Province, Malolos, *Templeton s. n.;* Norzagaray, *Bur. Sci. 12242 Foxworthy:* Rizal Province, San Mateo, *Loher 4553* (type collection of *Piper loheri* C. DC.), *4554, 4555;* Montalban, *Merrill 5039:* Manila, Singalong, *Bur. Sci. 12217 Ramos:* Laguna Province, Los Baños, Mount Maquiling, *Savella and Gates 5812, Osorio and Gates 6163, Elmer 18229:* Tayabas Province, Casiguran, *Bur. Sci. 45214 Ramos and Edaño.* In thickets and forests at low altitudes, ascending to 400 meters. Endemic.

Local names: Kadákad (Ilk.); kaláat (Ilk.); kalaskás (Tag.); litlít-kauáyan (Tag.); pamipamintahan (Tag.); sámat-anák (Pamp.).

This variety differs from the species in its elliptic-ovate to rounded-ovate leaves.

Var. CUMINGIANUM (Miq.) comb. nov. Text fig. 86, 7-11.

Piper cumingianum MIQ., Syst. Pip. (1843) 329, Fl. Ind. Bat. 1^2 (1858–59) 454; C. DC., Prodr. 16^1 (1869) 366; F.-VILL., Novis. App. (1880) 176; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219.

Piper samaranum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 223, Candollea 1 (1923) 217; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

Lamina narrowly elliptic-oblong to elliptic-lanceolate, 6 to 11.5 cm long, 2 to 4 cm wide, both apex and base acute, 5-nerved, sometimes 5-subplinerved.

LUZON, Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 33008 Ramos;* Mount Nagapatan, *Bur. Sci. 33180 Ramos:* Bontoc Subprovince, Bognen, *Vanoverbergh 558;* Gintadan, *Vanoverbergh 1184* (type collection of *Piper interruptum* Opiz forma *c* C. DC.); Bauco, *Vanoverbergh 1166;* Mount Polis, *Bur. Sci. 37665 Ramos and Edaño;* Mount Caua, *Bur. Sci. 37987 Ramos and Edaño:* Zambales Province, Candelaria, *Bur. Sci. 4813 Ramos:* Rizal Province, without definite locality, *Loher 13192;* Antipolo, *Bur. Sci. 22278 Ramos;* Mount Lumutan, *Bur. Sci. 29659, 29791 Ramos and Edaño;* Mount Angilog, *Bur. Sci. 40768 Ramos;* Mount Irig, *Bur. Sci. 42286 Ramos;* Mount Tokduanbanoy, *Bur. Sci. 48596, 48608 Ramos and Edaño:* Albay Province, without definite locality, *Cuming 1190* (type of *Piper cumingianum* Miq. in herb. Kew; isotype in herb. Manila). MINDORO, Paluan, *Bur. Sci. 39763 Ramos.* SAMAR, Cauayan Valley, *Bur. Sci. 17546 Ramos* (type collection of *Piper samaranum* C. DC.). LEYTE, Jaro, Masaganap, *Wenzel 613.* MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13582, 13837:* Davao Province, Mati, *Bur. Sci. 49084, 49133 Ramos and Edaño:* Zamboanga Province, Sax River mountains, *Merrill 8264.* In forests at low and medium altitudes, ascending to 1,000 meters. Endemic.

C. de Candolle reduced *Piper cumingianum* Miq. to a synonym of *Piper interruptum* Opiz, but I prefer to consider it as having varietal status. It differs from the species in the form of the lamina.

Var. LAEVIRAMEUM (C. DC.) comb. nov. Text fig. 85, 12.

Piper laevirameum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 450, Candollea 1 (1923) 215; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

Lamina broadly oblong, 15 to 16.5 cm long, 7.5 to 8.5 cm wide, 7-nerved; petioles about 2 cm long.

MINDANAO, Lanao Province, Camp Keithley, Lake Lanao, *Clemens 1255* (type of *Piper laevirameum* C. DC. in herb. Manila).

This variety differs from the species by its larger and typical broadly oblong leaves.

Var. MULTIPLINERVE C. DC. Text fig. 85, 13-14.

Piper interruptum Opiz var. *multiplinervum* C. DC. in Leafl. Philip. Bot. 3 (1910) 785, Philip. Journ. Sci. 5 (1910) Bot. 448, Candollea 1 (1923) 217; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

Piper interruptum Opiz var. *herbaceum* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 448, Candollea 1 (1923) 216; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

Piper interruptum Opiz var. *subarborescens* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 448, Candollea 1 (1923) 217; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

Piper subarborescens C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 222.

Piper loheri C. DC. forma *multiplinerve* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 450, 11 (1916) Bot. 223, Candollea 1 (1923) 216; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

Piper pilispicum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 452, Candollea 1 (1923) 269; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

Lamina broadly oblong to oblong-elliptic, 9.5 to 17.5 cm long, 3.5 to 8.5 cm wide, base 5-plinerved.

LUZON, Ilocos Norte Province, Mount Piao, *For. Bur. 12484 Merritt and Darling:* Benguet Subprovince, without definite locality, *Bur. Sci. 5720 Ramos* (type of *Piper pilispicum* C. DC. in herb. Manila); without definite locality, *For. Bur. 15865 Bacani:* Pangasinan Province, Mount San Isidro, Labrador, *Bur. Sci. 30015 Fénix:* Zambales Province, Mount Cabangaan, Butulan, *Bur. Sci. 26850 Edaño:* Bataan Province, Lamao, *Bur. Sci. 1870 Foxworthy* (type of *Piper interruptum* Opiz var. *multiplinerve* C. DC. in herb. Manila); Lamao River, Mount Mariveles, *Merrill 3182* (type of *Piper interruptum* Opiz var. *herbaceum* C. DC. in herb. Manila), *Elmer 6855, Whitford 1040:* Rizal Province, Bosoboso, *Bur. Sci. 4585* (type of *Piper interruptum* Opiz var. *subarborescens* C. DC. in herb. Manila), *1019 Ramos, For. Bur. 3299 Ahern's collector;* San Isidro, *Philip. Pl. 267 Ramos;* Montalban, *Loher 12375;* Mount Masungi, *Bur. Sci. 13615 Ramos;* Mount Susong-dalaga, *Bur. Sci. 29290 Ramos and Edaño;* Mount Lumutan, *Bur. Sci. 29670 Ramos and Edaño;* Mount Irid, *Bur. Sci. 41913 Ramos, Bur. Sci. 48523 Ramos and Edaño;* San Andales, *Bur. Sci. 48708, 48740, 48798, 48801 Edaño:* Laguna Province, Los Baños, *Baker 212, 1010, Gates and Harder 5872;* Mount San Cristobal, *Juliano 1086:* Sorsogon Province, Mount Bagacaua, *Bur. Sci. 23525 Ramos.* MINDORO, Paluan, *Bur. Sci. 39734 Ramos;* Mount Halcon, *Bur. Sci. 40608 Ramos and Edaño.* PANAY, Antique Province, Culasi, *Bur. Sci. 32310, 32321 McGregor.* MINDANAO, Surigao Province, Surigao, *Bur.*

Sci. 34428 Ramos and Pascasio: Agusan Province, Liluan Lake, *Weber 1204;* Cabadbaran, Urdaneta, *Elmer 14177:* Bukidnon Province, Mount Candoon, *Bur. Sci. 38831, 38833 Ramos and Edaño;* Tangkulan, *Bur. Sci. 39114 Ramos and Edaño.* In thickets and forests, at low and medium altitudes, ascending to 1,100 meters. Endemic.

Local names: Kaláscas (Tag.); litlít (Tag.); litlít-áso (Tag.).

After a critical comparison of the above reduced varieties and species I can suggest no other disposition of them. The striking feature of this variety is its plinerved lamina. The mature fruits are ovoid to globose, though in some cases they are ellipsoid. Four stigmas were not only found in var. *multiplinerve* but also in varieties *herbaceum* and *subarborescens* as well as in *Piper loheri* forma *multiplinerve* C. DC. Stamens in the varieties reduced vary from 2 to 3. *Piper acre* Blume is probably allied to this species.

73. **PIPER DAVAOENSE C. DC.** Text fig. 87.

Piper davaoense C. DC. in Perk. Frag. Fl. Philip. (1905) 154, Leafl. Philip. Bot. 3 (1910) 785, Philip. Journ. Sci. 5 (1910) Bot. 453, Candollea 1 (1923) 218; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

Piper laxirameum C. DC. in Leafl. Philip. Bot. 3 (1910) 779, Philip. Journ. Sci. 5 (1910) Bot. 443, Candollea 1 (1923) 219; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

A diœcious vine; the branches glabrous, smooth, terete, 1 to 2 mm in diameter. Leaves chartaceous, oblong to oblong-ovate, 5 to 9.5 cm long, 2 to 5.3 cm wide, base equilaterally to subequilaterally obtuse to rounded, 5-plinerved, sometimes 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations prominent beneath; petioles glabrous, 5 to 10 mm long, in the lower leaves up to 20 mm in length. Pistillate spikes long, pendulous, interrupted, 9.5 to 30 cm long, about 0.8 cm in diameter; peduncles glabrous, 1.5 to 2 cm long; rachis pilose; bracts long, adnate to the rachis, margins and apex free, oblong, subrounded, 3.75 to 4.25 mm long, 1 to 1.25 mm wide at the apex, glabrous above; fruits free, sessile, oblong to ovoid, 3.5 to 4 mm long, 2.25 to 2.5 mm in diameter, glabrous, black when dry; stigmas 3 or 4, ovoid, acute, sessile, apical. Staminate spikes greatly elongated, pendulous, 10 to 16.5 cm long, 3 to 3.5 mm in diameter; the peduncles glabrous, 3 to 4 cm long; rachis hirsute; bracts long, fully imbricate, membranaceous, adnate to the rachis, margins free, elliptic-obovate, 3 to 3.5 mm long, about 2 mm wide at the apex; stamens 3, sessile, never

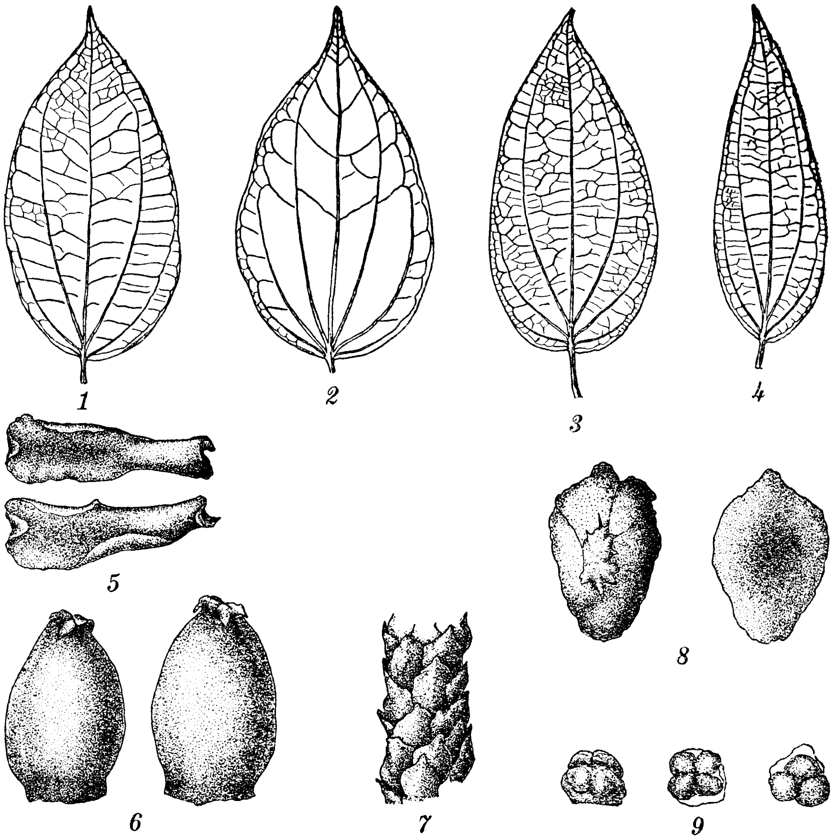


FIG. 87. *Piper davaoense* C. DC.; *1–4*, leaves, × 0.5; *5*, top view of pistillate bracts, × 7.5; *6*, fruits, × 7.5; *7*, portion of mature staminate spike, × 4.5; *8*, lower and upper views of staminate bracts, × 7.5; *9*, stamens, × 10.

exerted, two lateral and one posterior, anthers oblong, in the lateral stamens 4-valved, in the posterior one 3-valved.

MINDANAO, Davao Province, Mount Dagatpan, *Warburg 14740* (type of *Piper davaoense* C. DC. in herb. Berlin); Malita, *Copeland 676;* Todaya, Mount Apo, *Elmer 11065, 10503* (type collection of *Piper laxirameum* C. DC.). In forests, altitude from 600 to 1,300 meters. Endemic.

Local name: Manikatápai (Bag.).

The female plant is undoubtedly very close to *Piper interruptum* Opiz. The male plant with three stamens which are never exerted, differs from *Piper interruptum* Opiz by its fully imbricate, membranaceous, elliptic-obovate bracts.

74. PIPER PULOGENSE C. DC. Text fig. 88.

Piper pulogense C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 453, 11 (1916) Bot. 222, Candollea 1 (1923) 221; MERR., Enum. Philip. Fl. Pl. 2 (1923) 14.

A diœcious vine; the branches glabrous, terete, brown to black when dry, 1.5 to 3 mm in diameter. Leaves chartaceous, oblong-elliptic to ovate-elliptic, 7 to 9.5 cm long, 3.5 to 4.5 cm wide, base subequilaterally subacute, 5-nerved, apex acutely acuminate, gla-

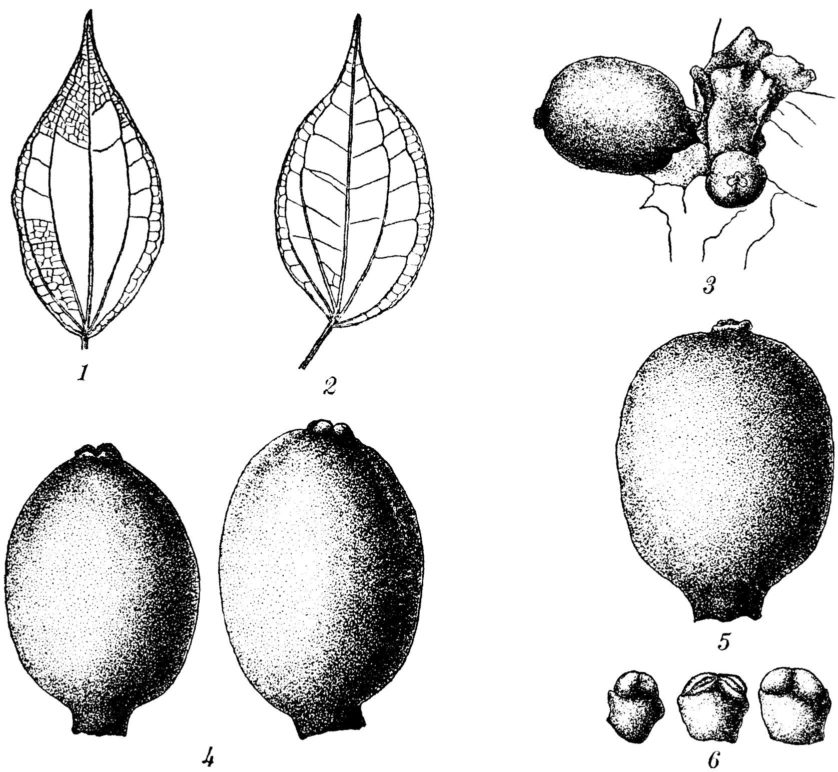


FIG. 88. *Piper pulogense* C. DC.; *1–2*, leaves, × 0.5; *3*, portion of pistillate spike, × 5; *4–5*, fruits, × 7.5; *6*, stamens, × 7.5.

brous on both surfaces; petioles glabrous, 1 to 1.5 cm long. Pistillate spikes pendulous, interrupted, 7.5 to 8.5 cm long, about 1 cm in diameter; the peduncles glabrous, 2.5 to 3 cm long; rachis glabrous; bracts long, adnate to the rachis, margins and apex free, glabrous, oblong-obovate, 2.5 to 3 mm long, 1.5 to 2 mm wide at the apex; fruits free, subsessile, oblong, 4 to 5.5 mm long, 2.5 to 3.5 mm in diameter, glabrous, black, the pedi-

cels up to 0.5 mm in length; stigmas 3 or 4, rounded, sessile, apical. Staminate spikes elongated, pendulous, 11 to 13.5 cm long, 2 to 2.5 mm in diameter; the peduncles glabrous, 1.5 to 2 cm long; rachis glabrous; bracts long, adnate to the rachis, margins and apex free, glabrous, membranaceous, oblong, rounded, 2.5 to 3 mm long, 0.75 to 1.2 mm wide at the apex, inflexed; stamens 2 or 3, pedicellate, 0.75 to 0.9 mm long, anthers subglobose, 2-valved, filaments oblong, about twice as long as the anthers.

LUZON, Benguet Subprovince, Mount Pulog, *For. Bur. 16240 Curran, Merritt, and Zschokke* (type of *Piper pulogense* C. DC. in herb. Manila); Mount Tonglon, *Philip. Pl. 749 Merrill.* In forests at high altitudes, ascending to 2,200 meters. Endemic.

This species, obviously allied to *Piper interruptum* Opiz, differs in its glabrous rachis and oblong fruits.

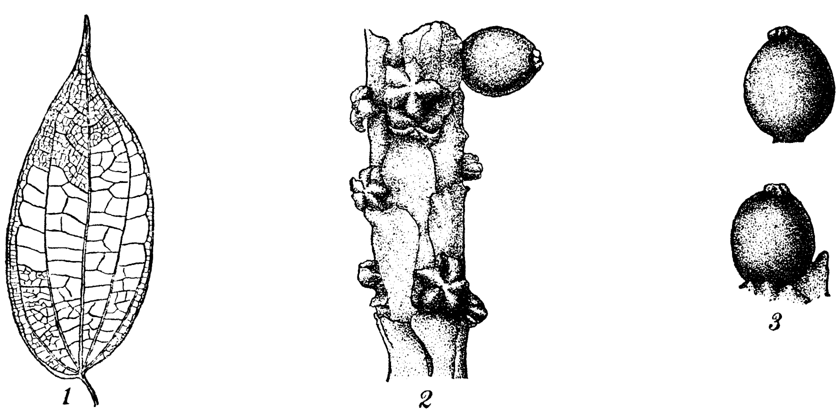


FIG. 89. *Piper multistigmum* C. DC.: *1*, leaf, × 0.5; *2*, portion of pistillate spike, enlarged; *3*, fruits, enlarged.

75. PIPER MULTISTIGMUM C. DC. Text fig. 89.

Piper multistigmum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 222, Candollea 1 (1923) 216; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

A diœcious vine; the branches glabrous, terete, brown, 1.5 to 2 mm in diameter. Leaves chartaceous, oblong, 8.5 to 9.7 cm long, 3 to 4 cm wide, base equilaterally to subequilaterally subrounded, 5-nerved, apex acutely acuminate, glabrous on both surfaces, reticulations more or less prominent on both surfaces; petioles glabrous, 1 to 1.5 cm long. Pistillate spikes elongated, pendulous, interrupted, 8 to 15 cm long, about 0.8 cm in diameter; the peduncles glabrous, 1 to 2 cm long; rachis pilose;

bracts long, adnate to the rachis, margins and apex free, glabrous, oblong-obovate, subobtuse to truncate, about 5.5 cm long, 1 mm wide at the apex; fruits free, sessile, very rarely subsessile, ovoid-globose, 3 to 4 mm long, 2.5 to 3 mm in diameter, glabrous, black; stigmas 5 or 6, linear, acute.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19819 McGregor* (type collection). Endemic.

An endemic species, in most characters closely resembling *Piper interruptum* Opiz but differing in the number of stigmas which is 5 or 6.

76. PIPER SPATHELLIFERUM sp. nov. Text fig. 90; Plate 15.

Frutex dioicus, scandens; ramulis glabris, laevis, obscure canaliculatis, teretibus, 1.5 ad 3.5 mm diametro; foliis subchartaceis, lanceolatis, 10 ad 11.5 cm longis, 2 ad 3.3 cm latis, basi aequilateralibus ad subaequilateralibus acutis, 5-nerviis, apice attenuatis, subtus fusco-punctulatis; petiolo glabro, 0.8 ad 1.3 cm longo; spicis ♀ 10 ad 16.5 cm longis, 1 cm diametro; pedunculis glabris, 1.5 ad 2.5 cm longis; rachis glabris; bracteis longis, ad rachis adnatis, spathulatis, apice marginibusque liberis, 4 ad 5 mm longis, 1.5 ad 2.5 mm latis; baccis glabris, in sicco nigris, sessilibus, liberis, oblongis, 4 ad 4.5 mm longis, 2.5 ad 3.2 mm diametro, apice obtusis ad rotundatis; stigmatibus 3 vel 4, ovoideis, acutis, sessilibus, adpressis, obscuris.

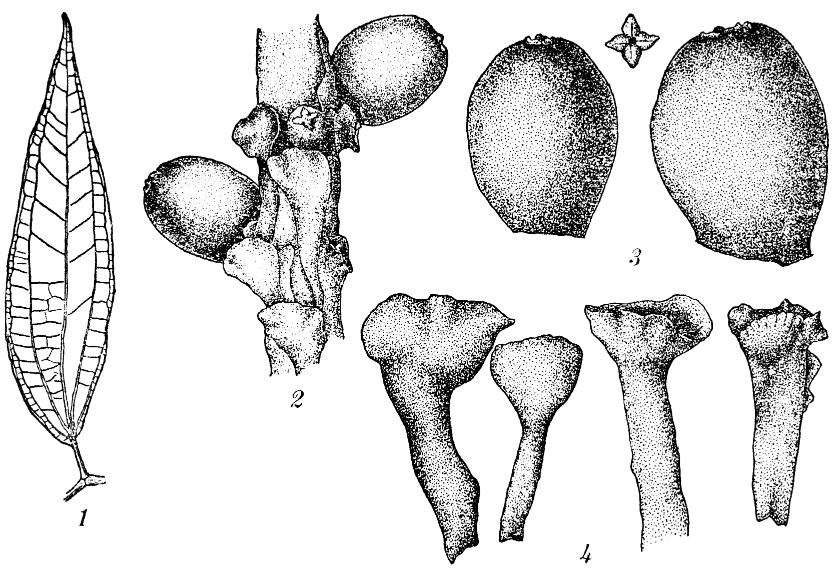


FIG. 90. *Piper spathelliferum* sp. nov.; *1*, leaf, × 0.5; *2*, portion of pistillate spike, × 5; *3*, two fruits and top view of stigmas, × 7.5; *4*, top view of bracts, × 10.

A diœcious vine; the branches glabrous, terete, 1.5 to 3.5 mm in diameter. Leaves subchartaceous, lanceolate, 10 to 11.5 cm long, 2 to 3.3 cm wide, base equilaterally to subequilaterally acute, 5-nerved, apex acutely acuminate, the lower surface with brown glandular dots, glabrous on both surfaces, reticulations obscure to obsolete on both surfaces; petioles glabrous, 0.8 to 1.3 cm long, in the lower leaves up to 2 cm in length. Pistillate spikes greatly elongated, pendulous, interrupted, 10 to 16.5 cm long, about 1 cm in diameter; the peduncles glabrous, 1.5 to 2.5 cm long; rachis glabrous; bracts long, adnate to the rachis, margins and apex free, glabrous, spathulate, 4 to 5 mm long, 1.5 to 2.5 mm wide at the apex; fruits free, sessile, oblong, 4 to 4.5 mm long, 2.5 to 3.2 mm in diameter, black when dry, glabrous, apex obtuse to rounded; stigmas 3 or 4, ovoid, acute, obscure, sessile, apical.

LUZON, Nueva Ecija Province, Mount Umingan, *Bur. Sci. 26383 Ramos and Edaño* (type in herb. Manila), August 20, 1916. A climbing vine on a small tree, in forests, on slopes near the summit of Mount Umingan, altitude about 400 meters.

The species is similar to *Piper elliptibaccum* C. DC. in most of its vegetative characters, but differs in the presence of glandular brown dots on the lower surface of the lamina. The most striking features are the long spathulate bracts, the oblong fruits, and the glabrous rachis.

77. **PIPER ELLIPTIBACCUM C. DC. Text fig. 91.**

Piper elliptibaccum C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 449, Candollea 1 (1923) 215; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

A diœcious vine; the branches glabrous, terete, 1.5 to 2 mm in diameter. Leaves chartaceous, lanceolate, 6.5 to 13.5 cm long, 1.5 to 3.8 cm wide, base equilaterally to subequilaterally acute, 5-nerved, rarely 5-plinerved, apex attenuate, glabrous on both surfaces, reticulations somewhat obscure to obsolete on both surfaces; petioles glabrous, 0.5 to 1 cm long, in the lower leaves up to 2.5 cm in length. Pistillate spikes greatly elongated, pendulous, interrupted, 9.5 to 15.5 cm long, about 0.8 cm in diameter; the peduncles glabrous, 1.5 to 2.5 cm long; rachis hirtellous; bracts long, adnate to the rachis, margins and apex free, glabrous, oblong-obovate, about 2.5 mm long, 1.5 mm wide at the apex; fruits free, sessile, elliptic-ovoid, 4 to 4.5 mm long, 2.5 to 3 mm in diameter, black, glabrous; stigmas 3 or 4, linear, acute, sessile, apical.

LUZON, Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 33025 Ramos:* Isabela Province, San Mariano, *Bur. Sci. 46951*

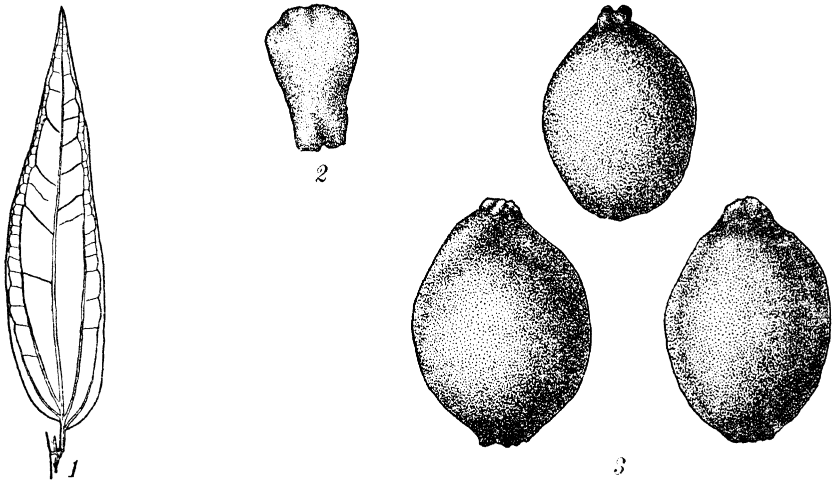


FIG. 91. *Piper elliptibaccum* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bract, × 7.5; *3*, fruits, × 7.5.

Ramos and Edaño: Camarines Sur Province, Maagnas, *Bur. Sci. 6344 Robinson* (type of *Piper elliptibaccum* in herb. Manila). CATANDUANES, Santo Domingo River, *Bur. Sci. 30385 Ramos.* In forests at low and medium altitudes, ascending to 330 meters. Endemic.

This species in its more significant characters is very near *Piper interruptum* Opiz, but differs in having lanceolate leaves and elliptic-ovoid fruits.

78. PIPER CLEMENSIAE C. DC. Text fig. 92.

Piper clemensiae C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 449, Candollea 1 (1923) 215; MERR., Enum. Philip. Fl. Pl. 2 (1923) 6.

A diœcious vine; the branches glabrous, terete, olivaceous, 2.5 to 4.5 mm in diameter. Leaves subcoriaceous, somewhat rugose, olivaceous, broadly ovate, 10.5 to 11.8 cm long, 6.5 to 7.5 cm wide, base equilaterally rounded, in the lower leaves cordate, 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations more or less obscure on both surfaces; petioles glabrous, 1.5 to 2 cm long, in the lower leaves up to 3.5 cm in length. Pistillate spikes greatly elongated, pendulous, interrupted, 22 to 34.5 cm long, about 1 cm in diameter; the peduncles glabrous, about 3 cm long; rachis hirsute; bracts long, adnate to the rachis, margins and apex free, oblong, 3.5 to 4.5 mm long, about 1.5 mm wide at the apex, glabrous; fruits free, sessile, oblong-ovoid to ovoid, 5 to 6 mm long, 3 to 3.5 mm in diameter, glabrous; stigmas 3, ovoid, fleshy, sessile, apical.

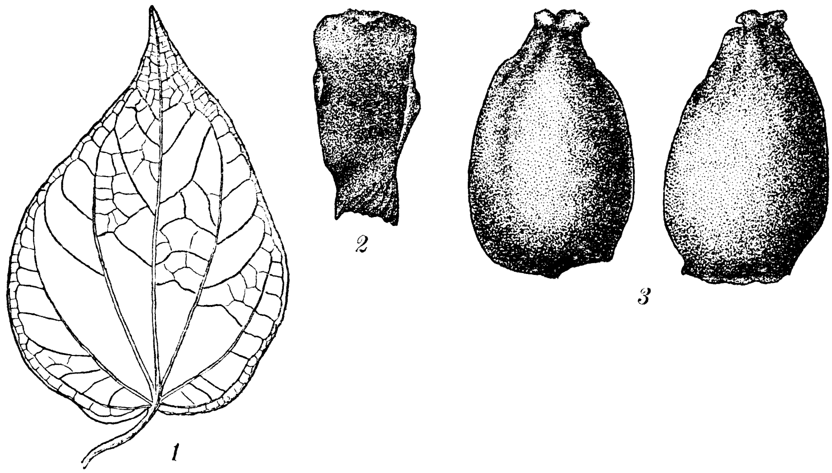


FIG. 92. *Piper clemensiae* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bract, × 7.5; *3*, fruits, × 7.5.

MINDANAO, Lanao Province, Camp Keithley, Lake Lanao, *Clemens 1200* (type in herb. Manila). Endemic.

A species closely allied to *Piper interruptum* Opiz, differing in its broadly ovate, subcoriaceous, rugose, olivaceous leaves and longer bracts.

79. PIPER NIGRUM Linn. var. TRIOICUM (Roxb.) C. DC. Text fig. 93; Plate 16.

Piper nigrum LINN., Sp. Pl. (1753) 28, var. *trioicum* (Roxb.) C. DC., Prodr. 16^1 (1869) 363, Candollea 1 (1923) 218; MERR., Enum. Philip. Fl. Pl. 2 (1923) 12.

Piper trioicum ROXB., Fl. Ind. 1 (1832) 151; MIQ., Syst. Pip. (1843) 310, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 51, *t. 51–52*.

Piper glabrispicum C. DC. in Perk. Frag. Fl. Philip. (1905) 155, Philip. Journ. Sci. 5 (1910) Bot. 451, Candollea 1 (1923) 217; MERR., Enum. Philip. Fl. Pl. 2 (1923) 9.

A triœcious vine; the branches glabrous, terete, 2 to 3.5 mm in diameter. Leaves chartaceous to subcoriaceous, ovate to oblong-elliptic, 7 to 11.5 cm long, 3.5 to 6.5 cm wide, base inequilaterally subacute to acute, 7-plinerved, apex shortly and acutely acuminate, glabrous on both surfaces, reticulations somewhat obscure above, more or less prominent beneath; petioles glabrous, 10 to 20 mm long. Hermaphroditic spikes suberect to pendulous, 4 to 8.5 cm long, about 0.8 cm in diameter; the peduncles glabrous, 7 to 15 mm long; rachis hirsute; bracts adnate to the rachis, margins and apex free, fleshy, oblong, glabrous above and on the margins; fruits with peculiar peppery odor and hot taste, sessile, not crowded, globose, rounded, about 4 mm long, 3 mm in diameter; stigmas 3 or 4, lanceolate, sessile,

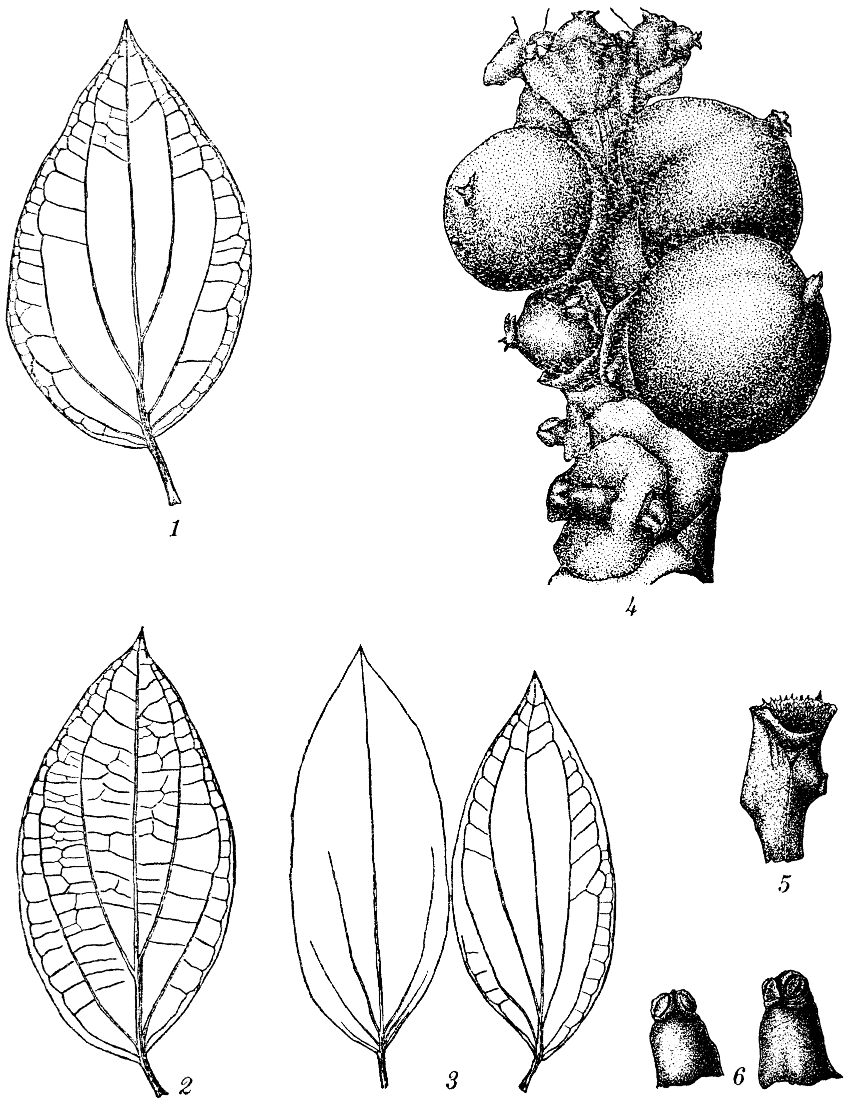


FIG. 93. *Piper nigrum* Linn. var. *trioicum* (Roxb.) C. DC.; *1–3*, leaves, × 0.5; *4*, portion of spike, × 7.5; *5*, top view of bract, × 7.5; *6*, stamens, × 10.

apical. Stamens 2, inserted at the base of the fruits or ovaries, about 1 mm long, anthers ovoid, bilocular, 2-valved, filaments oblong, twice as long as the anthers. Female spikes pendulous, 6.5 to 10.5 cm long; the peduncles glabrous, 15 to 23 mm long; rachis glabrous; bracts like the hermaphroditic ones, up to 4 mm in length; ovaries free, ovoid, sessile, stigmas 3, ovoid, acute, sessile, apical.

LUZON, Bataan Province, Lamao, *Bur. Sci. Quisumbing 76564:* Cavite Province, Mendez Nuñez, *Bur. Sci. 1339 Mangubat:* Laguna Province, Los Baños, *Juliano 1079a:* Batangas Province, Balayan, *Merr. Sp. Blancoanae 585.* MINDANAO, Davao Province, Taumo, *Warburg 14748* (type of *Piper glabrispicum* C. DC. in herb. Berlin).

Cultivated in all the tropical countries of the old world, and also in Brazil and in the West Indies. The Linnaean species was correctly interpreted by Blanco, the Philippine form being referable to the var. *trioicum* (Roxb.) C. DC. The pepper plant is cultivated only to a limited extent in the Philippines, and is known as *pimienta* (Sp.); *pamintá* and *malisa* (Tag.).

This variety is characterized by having ovate to oblong-elliptic leaves, by possessing fruits which are globose, black, aromatic in odor and hot in taste, and by being triœcious.

Section SARCOSTEMON

C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 413, Candollea 1 (1923) 71.

Leaves broadly elliptic-ovate to elliptic-lanceolate, 7- to 9-plinerved, base acute, rarely obtuse, rounded, or cordate. Spike solitary, leaf-opposed, greatly elongated and interrupted. Flowers diœcious. Bracts adnate to the rachis, margins and apex free. Fruits free, sessile. Stamen 1, filament swollen, fleshy.

80. PIPER KORTHALSII Miq. Text figs. 94 and 95.

Piper korthalsii MIQ. in Ann. Mus. Bot. Lugd.-Bat. 1 (1863) 139; C. DC., Prodr. 16[1] (1869) 365, Philip. Journ. Sci. 5 (1910) Bot. 414 (incl. var. *longibracteum* C. DC.), Leafl. Philip. Bot. 3 (1910) 763, Candollea 1 (1923) 71; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

Piper cristatum C. DC. in Leafl. Philip. Bot. 3 (1910) 770, Philip. Journ. Sci. 5 (1910) Bot. 428, Candollea 1 (1923) 198; MERR., Enum. Philip. Fl. Pl. 2 (1923) 7.

A diœcious vine; the branches glabrous, terete, angled, 2.5 to 8 mm. in diameter. Leaves chrataceous to subcoriaceous, broadly elliptic-ovate to elliptic-lanceolate, 10 to 21 cm long, 3.5 to 14 cm wide, base equilaterally to inequilaterally acute, rarely obtuse, rounded, or cordate, 7- to 9-plinerved, apex acute to shortly and acutely acuminate, glabrous on both surfaces, reticulations somewhat prominent on both surfaces; petioles glabrous, 12 to 25 mm long, in the lower leaves up to 50 mm in length. Pistillate spikes greatly elongated, pendulous, 13 to 25 cm long, about 1.5 cm in diameter; the peduncles glabrous, 15 to 40 mm long; rachis glabrous to hirtellous; bracts adnate to

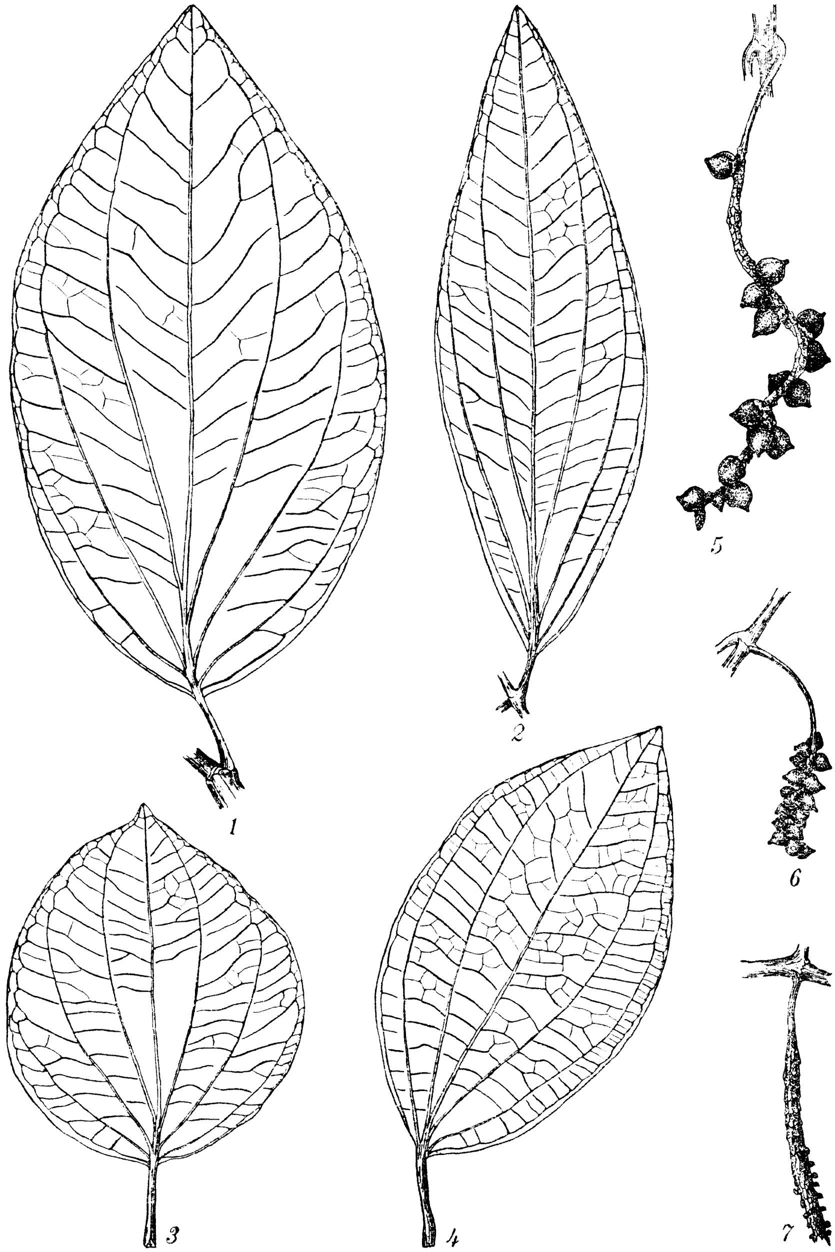


FIG. 94. *Piper korthalsii* Miq.; *1–4*, leaves, × 0.5; *5*, pistillate spike, × 0.5; *6*, part of pistillate spike, with crowded submature fruits, × 0.5; *7*, portion of staminate spike, × 0.5.

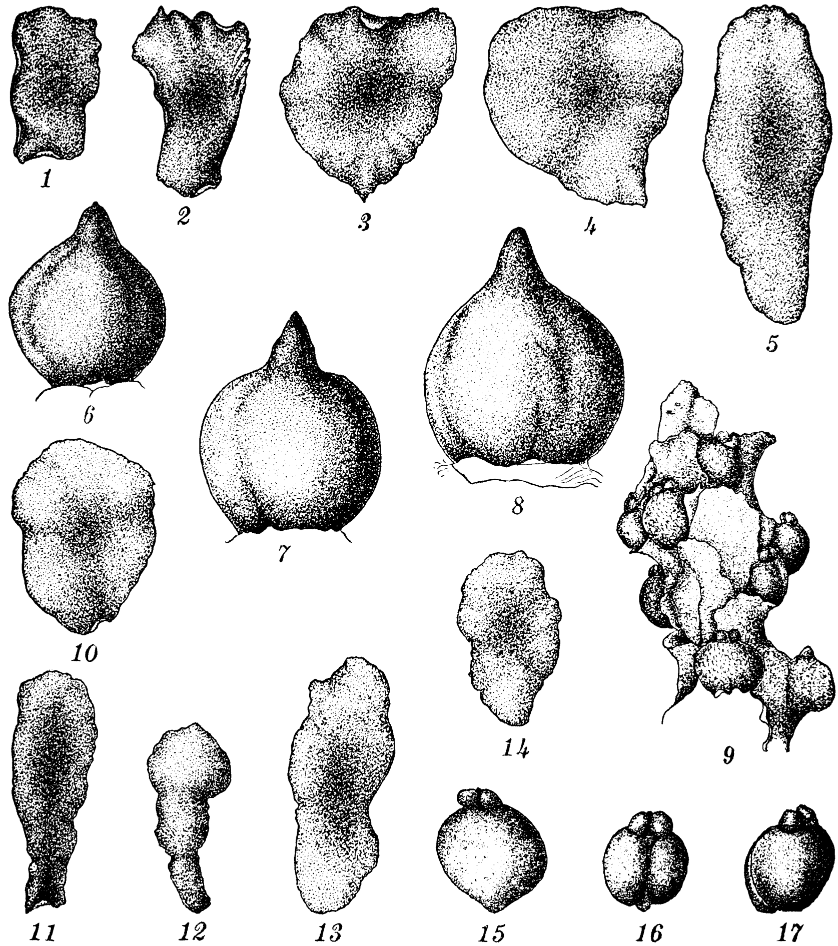


FIG. 95. *Piper korthalsii* Miq.; *1–5*, pistillate bracts, × 7.5; *6–8*, fruits, × 2.5; *9*, portion of staminate spike, × 7.5; *10–14*, staminate bracts, × 7.5; *15–17*, stamens in different views, × 10.

the rachis, margins and apex free, oblong to subrounded-obovate, 3 to 6 mm long, 1.5 to 3.5 mm wide, membranaceous, glabrous above and on the margins; ovaries ovoid-oblong, angled; fruits sessile, without a hot taste, somewhat crowded, ovoid, 5 to 8 mm long, 5 to 7.5 mm in diameter, apex rostrate-attenuate, acute; stigmas 3 or 5, lanceolate, puberulent, sessile, apical. Staminate spikes greatly elongated, pendulous, 12.5 to 31 cm long, 5 to 6 mm in diameter; the peduncles glabrous, 12 to 25 mm long; rachis hirtellous; bracts adnate to the rachis, margins and

apex free, imbricate, membranaceous, oblong to subspathulate, 3 to 5 mm long, 1.5 to 2.5 wide, glabrous above and on the margins; stamen 1, anthers apical, oblong, bilocular, 2-valved, loculi oblong, dehiscence introrse, filament swollen, fleshy, subglobose, exerted when mature, 1.25 to 1.5 mm long, 1 to 1.25 mm in diameter.

LUZON, Cagayan Province, trail from sitio Viola to Mount Nanig, *For. Bur. 19559 Curran:* Isabela Province, San Mariano, *Bur. Sci. 46972 Ramos and Edaño:* Apayao Subprovince, Abulug River, *Weber 1567;* Tamoe, *Bur. Sci. 13881 Ramos;* Guiniri, *Bur. Sci. 28228 Fénix:* Bontoc Subprovince, Bonco, *Vanoverbergh 1178, 2360:* Ifugao Subprovince, Mount Polis, *Bur. Sci. 19814 McGregor:* Benguet Subprovince, Sablang, *Philip. Pl. 471 Fénix;* San Fernando trail, *Merrill 7805;* Baguio, *Elmer 5896 5905, Bur. Sci. 2503 Mearns, Williams 1066:* Nueva Viscaya Province, Campote, *Bur. Sci. 14150 McGregor:* Rizal Province, Mount Irig, *Bur. Sci. 41884 Ramos;* Mount Irid, *Bur. Sci. 48427 Ramos and Edaño;* Montalban, *Loher 12609;* without definite locality, *Loher 14883, 15104:* Laguna Province, San Antonio, *Baker 3718, Bur. Sci. 10974, 16535, 23816 Ramos:* Tayabas Province, Casiguran, *Bur. Sci. 45559 Ramos and Edaño.* MINDORO, Mount Halcon, *Merrill 5592, Bur. Sci. 40702 Ramos and Edaño;* Pinamalayan, *Bur. Sci. 41113 Ramos;* Bongabong River, *For. Bur. 3702 Merritt.* LEYTE, Dagami, *Wenzel 470;* Jaro, Buenavista, *Wenzel 578, 638, 1107, 1130.* PANAY, Antique Province, Culasi, *Bur. Sci. 32295 McGregor:* Capiz Province, Jamindan, *Bur. Sci. 30863, 31014, 31311 Ramos and Edaño;* Mount Agramilig, *Bur. Sci. 46164 Edaño.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34544 Ramos and Pascasio;* Placer, *Wenzel 2533:* Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13726:* Lanao Province, Camp Keithley, Lake Lanao, *Clemens 463* (type collection of *Piper korthalsii* Miq. var. *longibracteum* C. DC.): Davao Province, Todaya, Mount Apo, *Elmer 10713* (type collection of *Piper cristatum* C. DC.). In forests at low, medium, and high altitudes, ascending to 2,000 meters. Sumatra.

Local names: Busok-búsok (Bag.); buyok-búyok (C. Bis.); dagóg (Mbo.); danód (Ig.); tápi (Ig.).

This species is characterized by having only one stamen. The anthers are borne on fleshy, swollen, subglobose filaments. The fruits are large, ovoid, with rostrate-attenuate apex; the bracts are adnate to the rachis with margins and apex free.

Section MULDERA

HOOK. f. in Fl. Brit. Ind. 5 (1890) 79; MIQ., Comm. Phyt. 34 (genus); *Schizonephros* GRIFF., Notul. 4 (1854) 383 (genus); C. DC., Prodr. 16^1 (1869) 241 (section), Candollea 1 (1923) 68.

Leaves oblong-elliptic, oblong-ovate or rounded-ovate, base acute to rounded, 5- to 7-plinerved. Spike solitary, leaf-opposed. Flowers diœcious. Bracts connate to the rachis, with ends fusing and forming sessile or stipitate cupular receptacles. Fruits distinctly remote, borne on sessile or stipitate cupular receptacles. Stamens 5 or 8, sunk in a cupular receptacle. India, Malaysia.

Key to the species.

1. Cupular receptacle sessile to subsessile, stamens 5........ 81. *P. baccatum*.
1. Cupular receptacle stipitate, stamens 8........................ 82. *P. sarcopodum*.

81. PIPER BACCATUM Blume. Text fig. 96; Plate 17, fig. 3.

Piper baccatum BLUME in Verh. Bat. Genoots. 11 (1826) 172, *t. 3;* C. DC., Prodr. 16^1 (1869) 241, Philip. Journ. Sci. 5 (1910) Bot. 462, Candollea 1 (1923) 70; MERR., Enum. Philip. Fl. Pl. 2 (1923) 4.
Muldera baccata MIQ., Syst. Pip. (1843) 341, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 58, *t. 59*.

A diœcious vine; the branches glabrous, terete, 2 to 4 mm in diameter. Leaves coriaceous, oblong-elliptic or rounded-ovate, 12 to 16.5 cm long, 4 to 9.5 cm wide, base equilaterally to subequilaterally acute to rounded, 5- to 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations somewhat obscure on both surfaces; petioles glabrous, 0.7 to 1.8 cm long, in the lower leaves up to 3 cm long. Pistillate spikes pendulous, 4.5 to 9.5 cm long, about 1.5 cm in diameter; the peduncles glabrous, 2 to 3 cm long; rachis glabrous, 1.5 to 2 mm in diameter; bracts connate to the rachis, with ends fusing and forming the cupular receptacle, glabrous; fruits globose, borne on the cupular receptacles, 4.5 to 6 mm long, 4 to 5 mm in diameter; stigmas 3 or 4, minutely puberulent, rounded; cupular receptacle sessile to subsessile, stout, glabrous outside, glabrous to ciliate on the rim, pilose inside. Staminate spikes pendulous, slender, 3 to 6 cm long, 2 to 2.25 mm in diameter; the peduncles glabrous, 1.6 to 2 cm long; rachis glabrous, slender, about 0.75 to 1 mm in diameter; bracts like the female; male flowers including the cupular receptacle about 2 mm long, 2 mm in diameter; stamens 5, small, sunk in the cupular receptacle, uniseriate; anthers very small, ovoid to subglobose, bilocular, 2-valved, erect, loculi oblong, filaments oblong, swollen at the base, slightly

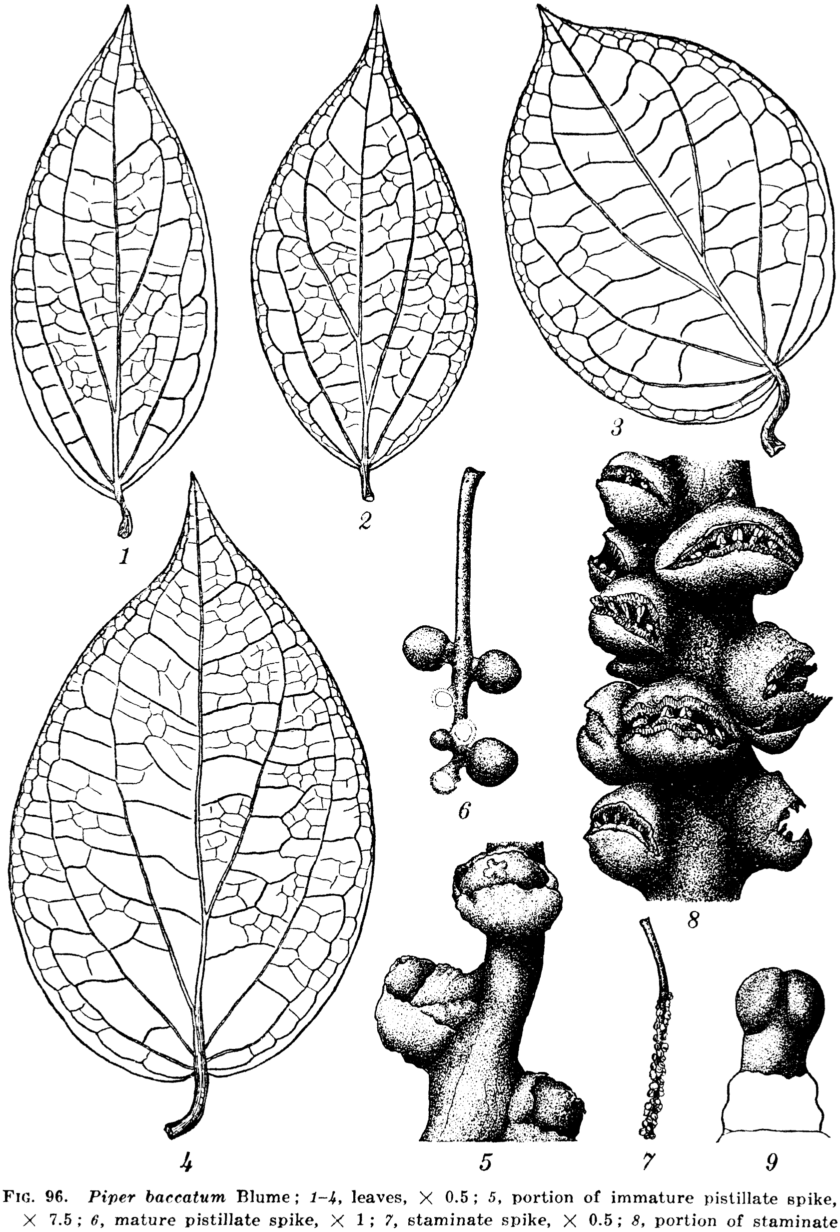


FIG. 96. *Piper baccatum* Blume; *1–4*, leaves, × 0.5; *5*, portion of immature pistillate spike, × 7.5; *6*, mature pistillate spike, × 1; *7*, staminate spike, × 0.5; *8*, portion of staminate spike, × 7.5; *9*, stamen, greatly enlarged.

longer than the anthers; cupular receptacles formed by the bracts, sessile, glabrous on the outside, pilose inside, rim oblique, ciliate, transverse, base constricted, apex rounded.

MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13972, 14210:* Lanao Province, Camp Keithley, Lake Lanao, *Clemens s. n.* 1907. In forests. Borneo, Java.

Local name: Sambañganai (Mbo.).

A species characterized by its fruits borne on sessile to subsessile cupular receptacles, the bracts connate to the rachis, stamens 5, uniseriate, sunken in the cupular receptacles.

82. **PIPER SARCOPODUM** C. DC. Text fig. 97; Plate 17, fig. 4.

Piper sarcopodum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 207, Candollea 1 (1923) 69; MERR., Enum. Philip. Fl. Pl. 2 (1923) 4.

A diœcious vine; the branches glabrous, terete, 1.5 to 4 mm in diameter. Leaves coriaceous, oblong-ovate to subrounded-ovate, 9.5 to 12 cm long, 5 to 7.5 cm wide, base equilaterally to inequilaterally subacute to rounded, 7-plinerved, apex acutely acuminate, glabrous on both surfaces, reticulations more or less obscure beneath; petioles glabrous, 10 to 15 mm long. Pistillate spikes pendulous, 6 to 9.5 cm long, 1.8 to 2.2 cm in diameter; the peduncles glabrous, 20 to 27 mm long; rachis glabrous, about 2 mm in diameter; bracts connate to the rachis, with ends fusing and forming the cupular receptacle; fruits distinctly remote, globose, borne on cupular receptacles, 5 to 6 mm long, 4 to 6 mm in diameter; stigmas 4, minute, rounded; cupular receptacles stipitate, stout, glabrous on the outside to very sparingly puberulent near the apex, glabrous on the rim, pilose inside. Staminate spikes pendulous, 4 to 5.5 cm long, 1 to 1.2 cm in diameter; the peduncles puberulent 12 to 28 mm long; rachis puberulent, slender, 0.75 to 1 mm in diameter; bracts like the female; male flowers including the cupular receptacles 5 to 6.75 mm long, 2.75 to 3.25 mm in diameter; stamens 8, minute, sunk in the cupular receptacle, uniseriate, anthers oblong, bilocular, 2-valved, erect, loculi elliptic-oblong, dehiscence apical, filaments oblong, swollen at the base, slightly longer than the anthers; cupular receptacles formed by the bracts, stipitate, puberulent outside, rim puberulent, transverse, not oblique, pilose inside, base constricted, apex obtuse to truncate, stalk slender, puberulent, 3 to 4 mm in length.

LUZON, Laguna Province, San Antonio, *Bur. Sci. 16536* (type collection), *23797 Ramos;* Los Baños, Mount Maquiling, *Elmer 17970:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16800.* In forests. Endemic.

This species shows most resemblance to *Piper baccatum* Blume in its vegetative features, but may be readily distinguished

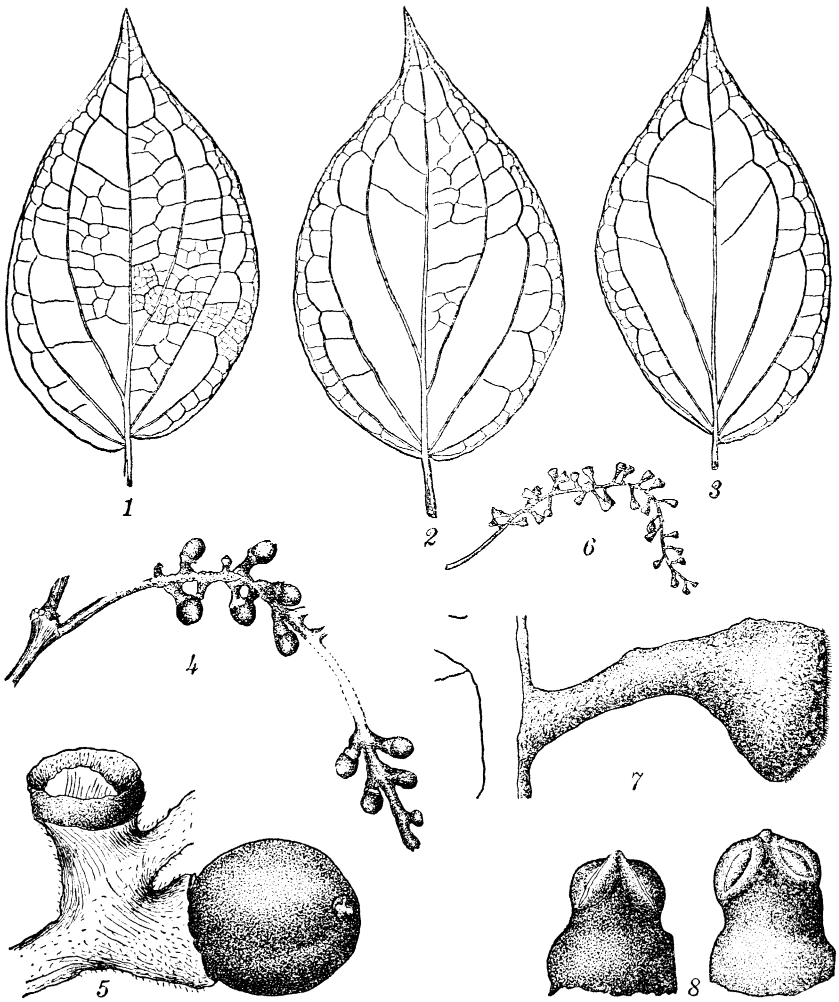


FIG. 97. *Piper sarcopodum* C. DC.; *1–3*, leaves, × 0.5; *4*, pistillate spike, × 0.5; *5*, cupular receptacles and a fruit, × 7.5; *6*, staminate spike, × 0.5; *7*, cupular receptacle with stamens, × 7.5; *8*, stamens, greatly enlarged.

by its prominently stipitate cupular receptacles and in having 8 stamens. *Elmer 16800* is labelled *Piper bulusanum* C. DC. in herb. de Candolle. This name has never been published.

Section PENNINERVIA sect. nov.

Bracteis ♀ a floribus distinctis, longe pedicellatis, peltatis. Floribus dioiceis. Staminibus 2 vel 3, connectivo supra loculo peltatem producto, carnoso. Baccis liberis, sessilibus, plerum-

que confertis. Stigmatibus plerumque 3 vel 4. Spicis oppositifoliis. Foliis penninerviis. Philippines.

Leaves various in form, penninerved. Spike solitary, leaf-opposed. Flowers diœcious. Bracts free, pedicellate, peltate. Fruits free, sessile, usually crowded. Stamens 2 or 3, the connective above the loculi of the anthers enlarged, fleshy. Stigmas usually 3 or 4. Philippines.

Key to the species.

1. Fruits crowded; stigma not sessile, up to 0.5 mm in length; lamina glaucous beneath.
    2. Lamina entirely glabrous on both surfaces; connective above the loculi subacute to truncate .... 83. *P. celtidiforme.*
    2. Lamina glabrous above, subglabrous to pubescent on the nerves beneath; connective above the loculi rounded.
        3. Branches glabrous; lamina oblong-elliptic to lanceolate-elliptic; petioles vaginate throughout their whole length with the bases broadly winged and chartaceous, glabrous. 83. *P. celtidiforme* var. *vaginans.*
        3. Branches pubescent; lamina lanceolate to oblong-ovate; petioles somewhat vaginate, pubescent .... 84. *P. catubigense.*
1. Fruits never crowded; stigma sessile; lamina never glaucous beneath.
    2. Lamina entirely glabrous on both surfaces; fruits never tubercular. 85. *P. penninerve.*
    2. Lamina glabrous above, pubescent beneath; fruits tubercular. 86. *P. villirache.*

83. PIPER CELTIDIFORME Opiz. Text figs. 98, 1–3, and 99.

Piper celtidiforme OPIZ in Presl. Rel. Haenk. 1 (1828) 152, *t. 26, f. 2;* C. DC., Prodr. 16[1] (1869) 377, Candollea 1 (1923) 230; F.-VILL., Novis. App. (1880) 76; MERR., Enum. Philip. Fl. Pl. 2 (1923) 6.

Chavica celtidiformis MIQ., Syst. Pip. (1843) 276.

Piper corylistachyon C. DC., Prodr. 16[1] (1869) 346 (incl. var. *magnifolia* C. DC.), Philip. Journ. Sci. 5 (1910) Bot. 438 (incl. formæ *b, c, d2* C. DC.), 11 (1916) Bot. 218, Leafl. Philip. Bot. 3 (1910) 776, Candollea 1 (1923) 188, 208; F.-VILL., Novis. App. (1880) 175; VIDAL, Phan. Cuming. Philip. (1885) 138, Rev. Pl. Vasc. Filip. (1886) 219; MERR., Sp. Blancoanae (1918) 118.

Chavica corylistachya MIQ., Syst. Pip. (1843) 281, Fl. Ind. Bat. 1[2] (1858–59) 447.

Piper obliquum BLANCO, Fl. Filip. (1837) 22, ed. 2 (1845) 16, ed. 3, 1 (1877) 30, non Ruiz and Pavon.

Piper warburgii C. DC. in Perk. Frag. Fl. Philip. (1905) 159, Candollea 1 (1923) 285.

A diœcious vine; the branches glabrous, terete, 1.5 to 5 mm in diameter. Leaves chartaceous, oblong-ovate, 9 to 17.5 cm long, 4 to 8.5 cm wide, base inequilaterally cuneate to rounded, penninerved, primary lateral nerves 4 or 5 or 6 on each side

of the midrib, apex acutely acuminate, glabrous on both surfaces, the lower surface glaucous, sometimes also the upper surface, reticulations usually obscure above, more or less prominent beneath; petioles glabrous, 10 to 15 mm long, in the lower leaves up to 30 mm in length. Pistillate spikes suberect, 1.6 to 4.5 cm long, 0.8 to 1.2 cm in diameter, rarely 6 cm long, 1.6 cm in diameter; the peduncles glabrous, 6 to 14 mm long; rachis villose; bracts long-pedicellate, peltate, 1.5 to 2 mm long, disk somewhat compressed, nearly 4-parted, glabrous above and on the margins, about 1 mm wide, pedicels villose; fruits crowded

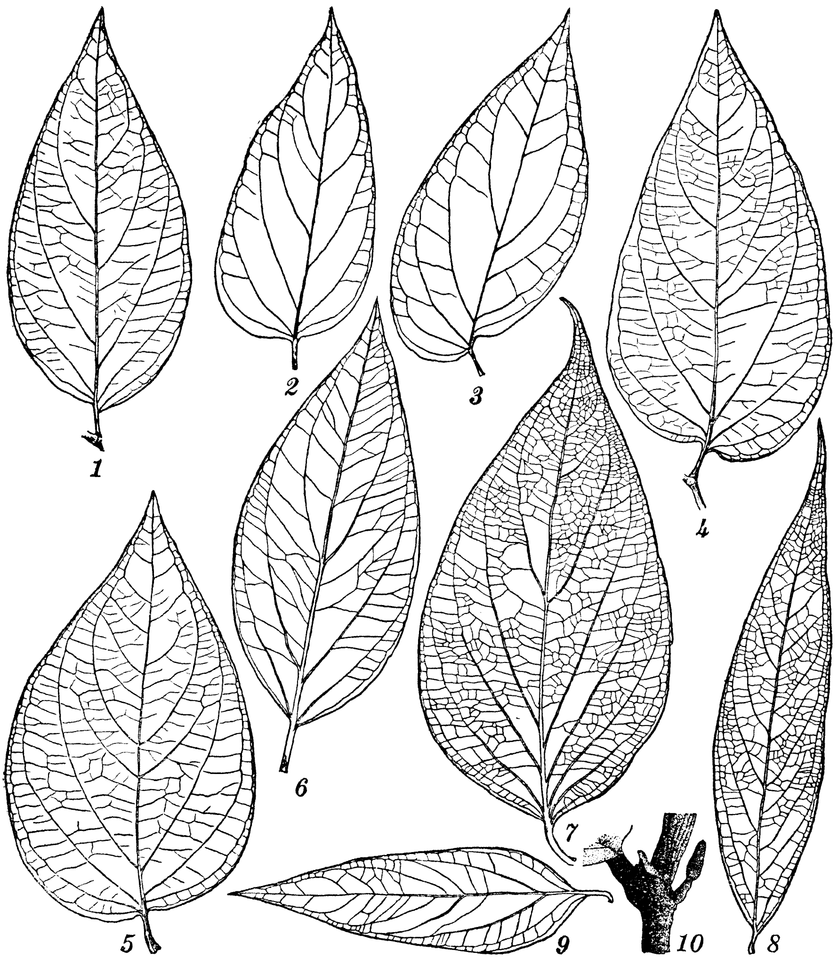


FIG. 98. Leaves of: *1–3*, *Piper celtidiforme* Opiz; *4–5*, forma *luzonense* (C. DC.) comb. nov.; *6–7*, forma *usteri* (C. DC.) comb. nov.; *8–9*, forma *tubuanense* forma nov., all × 0.3; *10*, var. *vaginans* var. nov., petiole, base of lamina, and young pistillate spike, × 1.

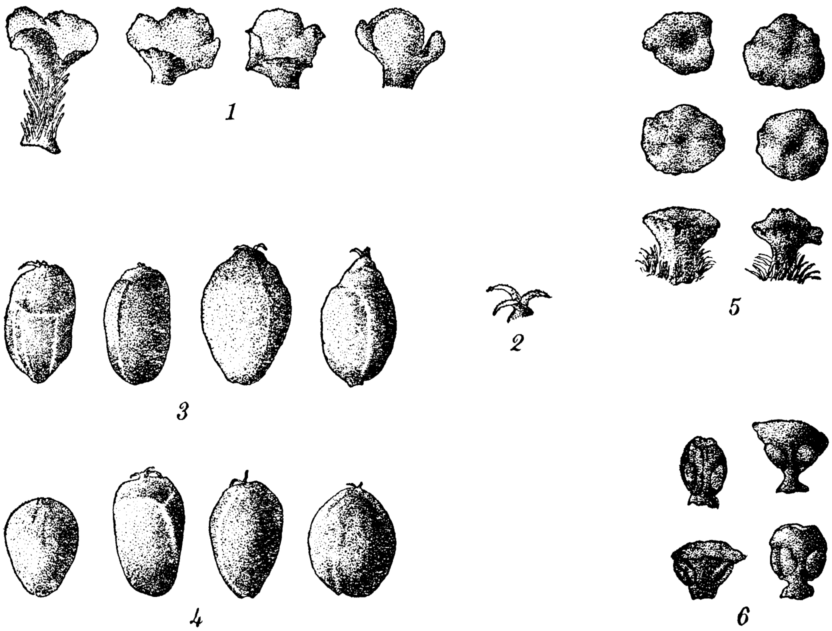


FIG. 99. *Piper celtidiforme* Opiz; *1*, pistillate bracts, × 10; *2*, stigmas, × 10; *3–4*, fruits, × 7.5; *5*, top and side views of staminate bracts, × 10; *6*, stamens, × 10.

with their bases partly embedded in and concrescent with the rachis, minute, ovoid, obovoid or oblong, 1.75 to 2.75 mm long, 1 to 1.5 mm in diameter; stigmas 3, rarely 4, linear, up to 5 mm in length, usually deciduous in the mature fruits. Staminate spikes suberect to subpendulous, cylindric, slender, 5 to 11.5 cm long, rarely 2.5 to 3.5 cm long, 4.5 to 5 mm in diameter; the peduncles glabrous, 3 to 3.2 cm long; rachis villose; bracts pedicellate, peltate, 0.75 to 1 mm long, disk glabrous above and on the margins, obovate to orbicular, 0.75 to 1 mm wide; stamens 2 or 3, usually 3, subsessile to pedicellate, very crowded, 0.75 to 1.25 mm long, anthers oblong, the connective above the loculi enlarged, peltate, fleshy, subacute to truncate, tetralocular, 4-valved, filaments somewhat exerted.

LUZON, without definite province and locality, *Haenke s. n.* 1792 (type of *Piper celtidiforme* Opiz in herb. Prague): Ilocos Norte Province, Bangui to Claveria, *Bur. Sci. 32967, 32987 Ramos:* Ilocos Sur Province, without definite locality, *Cuming 1044* [type of *Piper corylistachyon* C. DC. (*Chavica corylistachya* Miq.) in herb. Kew; isotype in herb. Manila]: Pangasinan Province, Umingan, *Bur. Sci. 18338 Otanes:* Nueva Ecija Prov-

ince, Caranglang, *Merrill 238:* Pampanga Province, Mount Abu, *Bur. Sci. 1989 Foxworthy;* Mount Arayat, *Warburg 13319, Merrill 1448, Bolster 21:* without definite province (central Luzon), Sampaloc, *Warburg 13116* (type of *Piper warburgii* C. DC. in herb. Berlin; isotype in herb. Manila); Bordeos, *Warburg 13320;* Mount Alban, *Warburg 12662:* Zambales Province, Anuling, *Bur. Sci. 44638 Ramos and Edaño;* Lamao River, Mount Mariveles, *Whitford 1280:* Rizal Province, Montalban, *Merr. Sp. Blancoanae 849;* Binangonan, *Warburg 13321;* Bosoboso, *Vidal 3541;* Antipolo, *Ramos s. n.;* Calamis River, *Bur. Sci. 13424 Ramos;* without definite locality, *Loher 14331:* Laguna Province, Paete, *Bur. Sci. 27859 McGregor;* San Antonio, *Bur. Sci. 12030, 20527 Ramos;* Los Baños, *Baker 1074;* Santa Cruz, *Gates and Teodoro 6498:* Tayabas Province, Tagcauayan, *Bur. Sci. 13324 Ramos;* Lucban, *Bur. Sci. 47401 McGregor, Elmer 8201a;* Infanta, *Bur. Sci. 6805 Robinson, Whitford 852:* Camarines Sur Province, without definite locality, *Vidal 1674:* Sorsogon Province, Mount Lalao, *Bur. Sci. 23406 Ramos.* POLILIO, *Bur. Sci. 6966, 6918 Robinson.* CARCRARAY (Albay Province), *Bur. Sci. 6407 Robinson.* SAMAR, Loquilocon, *Bur. Sci. 43808 McGregor;* without definite locality, *Vidal 512.* LEYTE, Tigbao, *Wenzel 1570.* PANAY, Iloilo Province, Suague River, *Bur. Sci. 18153 Robinson:* Antique Province, Tibiao, *Bur. Sci. 32296 McGregor.* BILIRAN, *Bur. Sci. 18775 McGregor.* In forests and thickets at low and medium altitudes, ascending to 250 meters. Endemic.

Local names: Litlít (Tag.); litlit-aníto (Tag.).

This characteristic species is easily distinguished from other known species of the Philippines by its peculiar anthers, the connective above the loculi enlarged, peltate and fleshy. It is further characterized by its crowded fruits, nearly 4-parted bracts, and the glaucous lower surfaces of the leaves.

Forma LUZONENSE (C. DC.) comb. nov. Text fig. 98, 4–5.

Piper luzonense C. DC., Prodr. 16^1 (1869) 350, Candollea 1 (1923) 258; F.-VILL., Novis. App. (1880) 175.

Piper reinwardtianum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 218, non C. DC., Prodr. 16^1 (1869) 354.

Piper corylistachyon C. DC. formæ *d* and *d2* C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 439.

Foliis late oblongo-ovatis ad late ovatis, 12.5 ad 24 cm longis, 6.5 ad 15 cm latis, basi rotundatis ad subcordatis.

LUZON, Apayao Subprovince, Abulug River, *Bur. Sci. 13882 Ramos:* Rizal Province, Bosoboso to Antipolo, *Bur. Sci. 42184 Ramos;* Atimonan, *Baker 3334;* Tanay, *Merrill 2306;* Sumag,

Loher 14116: Laguna Province, Pangil, *Bur. Sci. 27873 McGregor;* Paete, *Bur. Sci. 20525 Ramos;* Los Baños, Mount Maquiling, *Elmer 17774;* Lilio, *Elmer 6014:* Tayabas Province, Atimonan, *Gregory 110* (type collection of *Piper corylistachyon* C. DC. forma *d2* C. DC.) ; Mount Binuang, *Bur. Sci. 28520 Ramos and Edaño;* Casiguran, *Bur. Sci. 45202 Ramos and Edaño:* Camarines Sur Province, Niog, *Philip. Pl. 1575 Ramos:* Albay Province, Mount Mayon, *Bur. Sci. 6462 Robinson:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16224, 16225:* without definite province or locality, *Jagor 722* (type of *Piper luzonense* C. DC. in herb. Berlin). POLILLO, *Bur. Sci. 10235 McGregor.* MARINDUQUE, unknown collector. MINDORO, Paluan, *Bur. Sci. 39700 Ramos;* Pinamalayan, *Bur. Sci. 40900 Ramos.* SAMAR, Catbalogan, *Bur. Sci. 17420 Ramos.* LEYTE, without definite locality, *For. Bur. 11572 Whitford;* Tigbao, *Wenzel 1487.* CEBU, Catmon, *For. Bur. 12434 Danao.* NEGROS, *Piper 18.* PANAY, Iloilo Province, Tigom River, *Bur. Sci. 18134 Robinson* (determined by C. de Candolle as *Piper reinwardtianum* C. DC.) : Capiz Province, Mount Bomlon, *Bur. Sci. 21230 Escritor;* Jamindan, *Bur. Sci. 31225 Ramos and Edaño.* BILIRAN, *Bur. Sci. 18785 McGregor.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34426 Ramos and Pascasio:* Davao Province, Baganga, *Bur. Sci. 15859 Fénix.* In forests and thickets at low and medium altitudes, ascending to 650 meters. Endemic.

Local names: Baligágod (Neg.) ; buyo-bóyo (Bis.) ; litlít-aníto (Tag.) ; litlít-báboy (Tag.) ; litlít-matsíng (Tag.).

This form differs from the species by its larger leaves with rounded to subcordate bases.

Forma USTERI (C. DC.) comb. nov. Text fig. 98, 6–7.

Piper usteri C. DC. in Vierteljahrschr. Naturf. Ges. Zürich 50 (1905) 447 [Usteri Beitr. Ken. Philip. Veg. (1905) 125], Fedde Repert. 5 (1908) 64, Candollea 1 (1923) 284, Philip. Journ. Sci. 5 (1910) Bot. 439.

Piper corylistachyon C. DC. forma *c* C. DC. in Philip. Journ. Sci. 5 (1910) 439.

Foliis late oblongo-ellipticis ad late ovatis, 13 ad 21.5 cm longis, 6 ad 14 cm latis, basi subacutis ad acutis.

LUZON, Rizal Province, Antipolo, *Bur. Sci. 11867 Robinson and Ramos, Philip. Pl. 272 Ramos;* without definite locality, *Loher 14338, 15111:* Laguna Province, *Bur. Sci. 23811 Ramos;* Los Baños, *For. Bur. 20367 Villamil:* Tayabas Province, Atimonan, *Whitford 733;* Infanta, *Bur. Sci. 6806 Robinson:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 16507.* MINDORO,

McGregor 331; Lake Naujan, *For. Bur. 6875 Merritt;* Cauayan, *For. Bur. 4113.* SAMAR, Lanang, *Merrill 5236.* GUIMARAS, *Usteri s. n.* (type of *Piper usteri* C. DC. in herb. Manila). BOHOL, Bilar, *Bur. Sci. 42878 Ramos.* PANAY, Capiz Province, Mount Madiaas, *Bur. Sci. 30628 Ramos and Edaño;* Jamindan, *Bur. Sci. 31068, 31093 Ramos and Edaño;* Agraman, *Bur. Sci. 46142 Edaño;* Locero, *Bur. Sci. 46107, 46183 Edaño:* Antique Province, Culasi, *Bur. Sci. 32308 McGregor.* MINDANAO, Surigao Province, Surigao, *Piper 208;* Placer, *Wenzel 1881:* Zamboanga Province, Malangas, *Bur. Sci. 37031 Ramos and Edaño.* In forests and thickets at low and medium altitudes, ascending to 250 meters. Endemic.

Local names: Buyo-bóyo (Bis.); litlít-mátsing (Tag.).

This form differs from the preceding one by its leaves with bases subacute to acute.

Forma TUBUANENSE forma nov. Text fig. 98, 8–9.

Foliis lanceolatis ad elliptico-lanceolatis, 9 ad 20.5 cm longis, 3 ad 6.5 cm latis, basi acutis.

Leaves lanceolate to elliptic-lanceolate, 9 to 20.5 cm long, 3 to 6.5 cm wide, base acute.

MINDORO, Paluan, *Bur. Sci. 39588 Ramos.* LEYTE, Malitbog, *Weber 1523;* Tigbao, *Wenzel 1276.* MINDANAO, Surigao Province, Surigao, *Bur. Sci. 34359 Ramos and Pascasio:* Zamboanga Province, Mount Tubuan, *Bur. Sci. 36704 Ramos and Edaño* (type in herb. Manila); Malangas, *Bur. Sci. 37102, 37272, 37325, 37438 Ramos and Edaño.* BASILAN, *Hallier s. n.* 1904. In thickets and forests at low altitudes.

This form is characterized by its lanceolate to elliptic-lanceolate leaves.

Var. VAGINANS var. nov. Text figs. 98, 10.

Foliis oblongo-ellipticis ad lanceolato-ellipticis, 12 ad 16 cm longis, 3 ad 7 cm latis, basi subaequilateralibus acutis, apice longe et tenuiter acute acuminatis, supra glabris, subtus subglabris vel ad nervis hirtellis; petiolis brevibus, ad basi late vaginatis, membranaceis, 4 ad 8 mm longis.

Leaves oblong-elliptic to lanceolate-elliptic, 12 to 16 cm long, 3 to 7 cm wide, base subequilaterally acute, apex long, slender, and acutely acuminate, glabrous above, subglabrous to hirtellous on the nerves beneath; petioles short, vaginate the whole length, the base broadly winged, the wings membranaceous, 4 to 8 mm long.

LUZON, Ifugao Subprovince, Mount Polis, *Bur. Sci. 19822 McGregor* (type in herb. Manila): Kalinga Subprovince, Mount Masingit, *Bur. Sci. 37513, 37567 Ramos and Edaño.* In forests, altitude about 1,500 meters.

Notwithstanding the marked foliar differences stated, these plants show such coincidence in inflorescence and other characters as to discourage their treatment as independent species. The striking feature of this variety is the winged petiole.

84. **PIPER CATUBIGENSE** Merr. Text fig. 100.

Piper catubigense MERR. in Philip. Journ. Sci. 17 (1920) 244, Enum. Philip. Fl. Pl 2 (1923) 6.

A diœcious vine; the branches tomentose, terete, 2 to 3.5 mm in diameter. Leaves membranaceous to chartaceous, lanceolate to oblong-ovate, 11 to 22 cm long, 3.5 to 12.5 cm wide, base subequilaterally obtuse to rounded, penninerved, lateral nerves 6 to 8 on each side of the midrib, apex acutely acuminate, glabrous above, tomentose on the nerves beneath, reticulations, prominent on both surfaces; petioles tomentose, 7 to 12 mm long. Pistillate spikes suberect, short, 17 to 25 mm long, 10 to 15 mm in diameter; the peduncles tomentose, 7 to 13 mm long; rachis tomentose; bracts long-pedicellate, peltate, 1.5 to 2 mm long, disk somewhat compressed, glabrous above and on the margins, about 0.75 mm wide, pedicels somewhat slender, tomentose; fruits crowded, with their bases partly embedded in and concrescent with the rachis, minute, oblong to oblong-obovoid, 2 to 2.5 mm long, 1 to 1.25 mm in diameter; stigmas 3, linear, up to 0.4 mm long, deciduous in the mature fruits. Staminate spikes erect, 5 to 7 cm long, 2.5 to 3.5 mm in diameter, black when dry; the peduncles tomentose, 8 to 13 mm long; rachis tomentose; bracts pedicellate, peltate, about 0.75 mm long, disk glabrous above and on the margins, orbicular, about 1 mm wide; stamens 2 or 3, subpedicellate, crowded, 1 to 1.2 mm long, anthers oblong, to oblong-obovoid, rounded, connective above the loculi enlarged, fleshy, tetralocular, 4-valved, dehiscence lateral, filaments much shorter than the anthers.

CATANDUANES, Calolbong, *Bur. Sci. 30249, 30256 Ramos and Chan.* SAMAR, Catubig River, *Bur. Sci. 24278 Ramos* (type in herb. Manila). In damp forests at low altitudes. Endemic.

A species with reproductive structures clearly resembling those of *Piper celtidiforme* Opiz, differing radically in its pubescent branches, petioles, peduncles, and the nerves on the lamina beneath. The connective of the anthers is rounded.

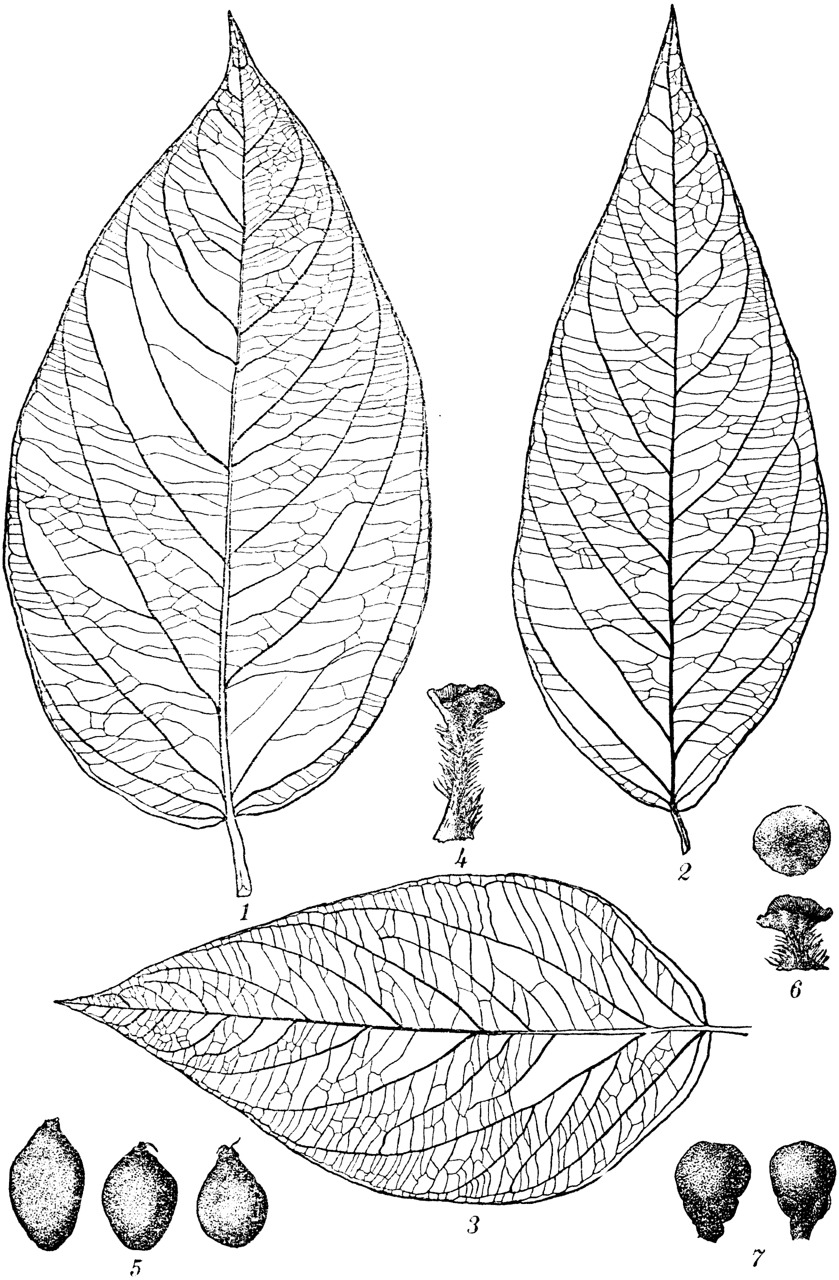


FIG. 100. *Piper catubigense* Merr.; *1–3*, leaves, × 0.5; *4*, pistillate bract, × 10; *5*, fruits, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

85. **PIPER PENNINERVE** C. DC. Text fig. 101.

Piper penninerve C. DC. in Perk. Frag. Fl. Philip. (1905) 157, Philip. Journ. Sci. 5 (1910) Bot. 440, 11 (1916) Bot. 218, Candollea 1 (1923) 210; MERR., Enum. Philip. Fl. Pl. 2 (1923) 13.

A diœcious vine; the branches glabrous, terete, 1.25 to 3 mm in diameter. Leaves chartaceous, elliptic-lanceolate to broadly oblong-elliptic, 10 to 20 cm long, 3.5 to 8.5 cm wide, base equilaterally to subequilaterally acute, penninerved, lateral nerves 8 to 11 on each side of the midrib, apex acutely acuminate, glabrous on both surfaces, never glaucous beneath, usually dark brown when dry, reticulations somewhat obscure above, prominent beneath; petioles glabrous, 5 to 10 mm long, in the lower leaves up to 15 mm in length. Pistillate spikes rather short, recurved, 1.5 to 2.8 cm long, 5.5 to 8 mm in diameter; the peduncles glabrous, 5 to 17 mm long; rachis villose; bracts long-pedicellate, peltate, 1.75 to 2.25 mm long, disk glabrous above and on the margins, firm, subrounded-obovate, 1 to 1.25 mm wide, pedicels rather stout, villose; fruits never crowded, with their bases about half embedded in and concrescent with the rachis, obovoid to globose-obovoid, usually tetragonous, apex subacute, 2 to 2.5 mm long, 1.5 to 2 mm in diameter; stigmas 3 or 4, rarely 5, ovoid, acute, sessile, apical; seeds reddish black to black, globose-obovoid to globose, 1.5 to 1.75 mm long. Staminate spikes suberect to subpendulous, 4.5 to 9.5 cm long, 1.75 to 2.5 mm in diameter, rarely 2.5 cm long; the peduncles glabrous, 7 to 16 mm long; rachis villose; bracts pedicellate, peltate, 0.5 to 0.75 mm long, disk glabrous above and on the margins, subrounded-obovate, about 0.75 mm wide; stamens, 2, sessile, becoming pedicellate after dehiscence, up to 1.25 mm long, anthers obovoid to subglobose, tetralocular, 4-valved, dehiscence lateral, connective above the loculi enlarged, fleshy, rounded, filaments as long as the anthers, somewhat exerted.

LUZON, Rizal Province, San Isidro, *Bur. Sci. 13396 Ramos;* Mount Angilog, *Bur. Sci. 40775 Ramos;* Mount Irid, *Bur. Sci. 42284 Ramos:* Camarines Sur Province, Bagacay, *Bur. Sci. 33857 Ramos and Edaño.* SAMAR, Catubig River, *Bur. Sci. 24284 Ramos.* LEYTE, Jaro, Buenavista, *Wenzel 719;* Dagami, *Bur. Sci. 15230 Ramos, Wenzel 2, 374.* BOHOL, Bilar, *Bur. Sci. 42877 Ramos.* MINDANAO, Davao Province, Dagatpan, *Warburg 14744* (type in herb. Berlin) : Zamboanga Province, Port Banga, *Bur. Sci. 11818 Robinson.* SIARGAO, *Bur. Sci. 34949 Ramos and Pascasio.* In forests at low, medium, and high altitudes, ascending to 1,300 meters. Endemic.

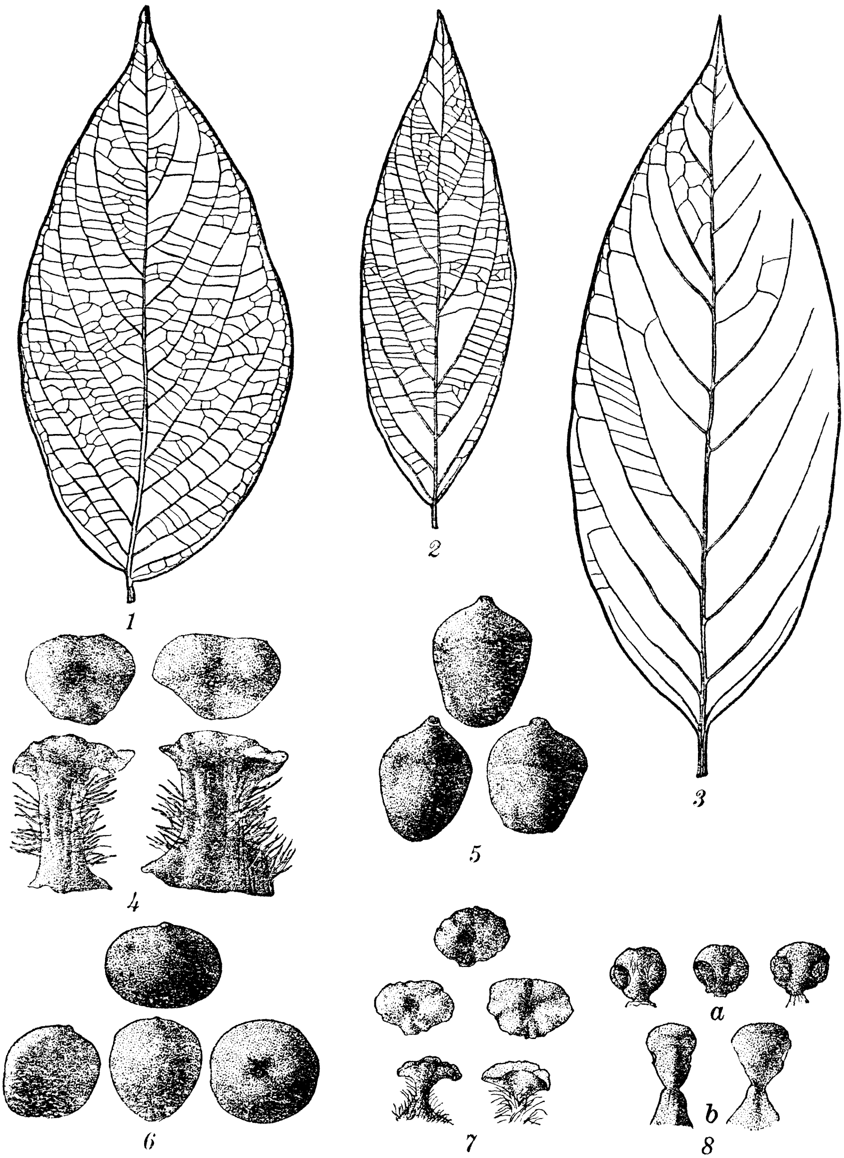


FIG. 101. *Piper penninerve* C. DC.; *1–3*, leaves, × 0.5; *4*, top and side views of pistillate bracts, × 10; *5*, fruits, × 7.5; *6*, different views of seeds, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, *a*, before dehiscence; *b*, after dehiscence, × 10.

This species is apparently closely allied to *Piper celtidiforme* Opiz, by its peculiar anthers, differing in its smooth, never glaucous, lower surfaces of the leaves, its fruits never crowded

and more or less embedded in and concrescent with the rachis, and in its sessile stigmas.

86. PIPER VILLIRACHE C. DC. Text fig. 102.

Piper villirache C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 214, Candollea 1 (1923) 285; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

Piper longilimbum C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 221, Candollea 1 (1923) 211; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

A diœcious vine; the branches glabrous, subterete, 4 to 8 mm in diameter. Leaves membranaceous to subchartaceous, broadly oblong to broadly oblong-elliptic, 17 to 34 cm long, 8 to 15 cm wide, base subinequilateral, usually acute, rarely obtuse or rounded, penninerved, lateral nerves 7 to 10 on each side of the midrib, apex shortly and acutely acuminate, rarely long-acuminate, covered with conspicuous reddish-brown dots on both

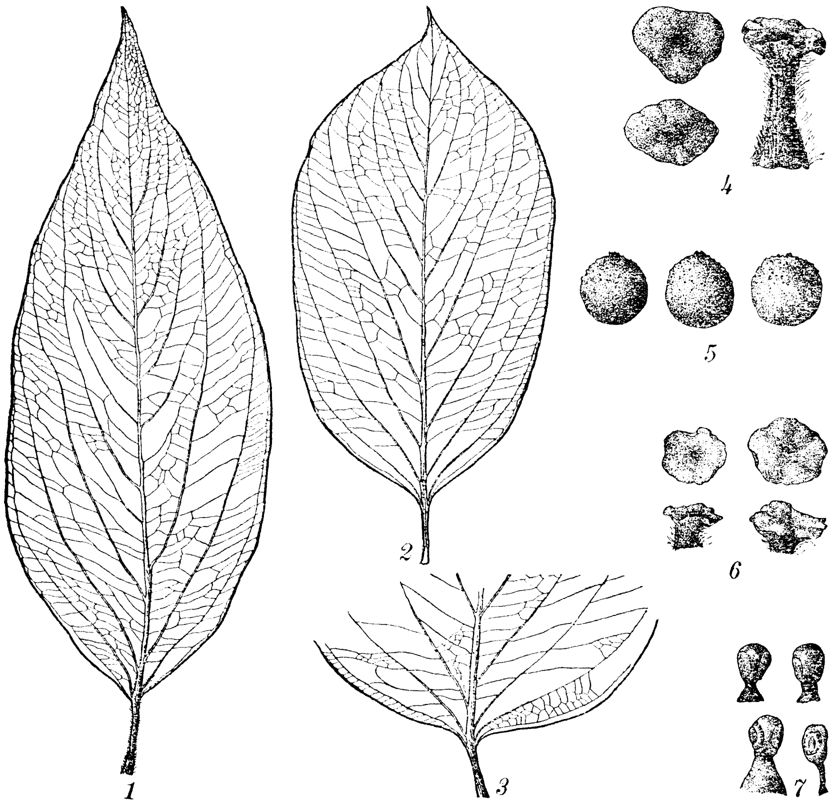


FIG. 102. *Piper villirache* C. DC.; *1–2*, leaves, × 0.3; *3*, leaf base, × 0.3; *4*, top and side views of pistillate bracts, × 6.5; *5*, fruits, × 5; *6*, top and side views of staminate bracts, × 6.5; *7*, stamens, × 6.5.

surfaces, glabrous above, hirsute beneath; petioles sparingly hirsute to hirsute, 10 to 30 mm long, in the lower leaves up to 35 mm in length. Pistillate spikes suberect, elongated, 5 to 7.5 cm long, 5 to 7 mm in diameter; the peduncles glabrous, 10 to 35 mm long; rachis densely villose; bracts long-pedicellate, peltate, 1.75 to 2.25 mm long, disk glabrous above and on the margins, somewhat fleshy, subelliptic to obovate, 1.5 to 2 mm wide, pedicels villose; fruits never crowded, partly embedded in and concrescent with the rachis, globose to globose-ovoid, turbercular near the apex, 2 to 2.25 mm long, 1.75 to 2 mm in diameter; stigmas 3 or 4, oblong, sessile, apical. Staminate spikes suberect to erect, greatly elongated, black when dry, 10.5 to 15 cm long, 2.5 to 4 mm in diameter; the peduncles sparsely pilose, 10 to 40 mm long; rachis pilose; bracts subpedicellate to pedicellate, peltate, 0.5 to 0.75 mm long, disk glabrous above and on the margins, fleshy, obovate to orbicular, 1 to 1.25 mm wide; stamens 2, subsessile, becoming pedicellate after dehiscence, up to 1.5 mm in length, anthers obovoid to oblong, connective above the loculi enlarged, fleshy, rounded, loculi large, bilocular, 2-valved, dehiscence lateral, filaments as long as the anthers, somewhat swollen at the base.

SAMAR, Mount Canislagan, *Bur. Sci. 17602 Ramos* (type collection of *Piper longilimbum* C. DC.); Catubig River, *Bur. Sci. 24307 Ramos.* BOHOL, Bilar, *Bur. Sci. 42752 Ramos.* MINDANAO, Surigao Province, Placer, *Wenzel 3201:* Agusan Province, Waloe, Agusan River, *Merrill 7280:* Davao Province, Mount Mayo, *Bur. Sci. 49461 Ramos and Edaño:* Bukidnon Province, Sumilao, *Bur. Sci. 15773 Fénix* (type collection of *Piper villirache* C. DC.): Zamboanga Province, Malangas, *Bur. Sci. 36853, 36857, 36889, 36989 Ramos and Edaño.* In forests at low and medium altitudes, ascending to 700 meters. Endemic.

Local names: Parong-dagkó (S. L. Bis.); tugpuán (Buk.).

A species close to *Piper celtidiforme* Opiz, differing essentially in its thick branches, hirsute lower surface of the leaves, tubercular fruits, and rounded connective.

Section ZIPPELIA sect. nov.

Blume in Roem. et Schultes, Syst. Veg. 7 (1830) 1614, 1651 (genus).

Leaves oblong-ovate to ovate, base cordate, 5-nerved. Spike solitary, leaf-opposed. Flowers bisexual. Bracts sessile, peltate, base adnate to the rachis, apex cucullate. Fruits glochidiate, pedicellate, remote. Stamens 6.

87. PIPER BEGONIAEFOLIUM (Blume) comb. nov. Text fig. 103.

Zippelia begoniaefolia BLUME in Roem et Schultes, Syst. Veg. 7 (1830) 1614, 1651; MIQ., Syst. Pip. (1843) 548, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 82, *t. 92 f. c.;* MERR., Philip. Journ. Sci. 13 (1918) Bot. 6, Enum. Philip. Fl. Pl. 2 (1923) 18.

Zippelia lappacea BENN. in Pl. Jav. Rar. (1838) 76, *t. 16*.

Piper zippelia C. DC., Prodr. 16^1 (1869) 256, Candollea 1 (1923) 71.

Piper lappaceum C. DC. in Lecomte Fl. Gén. Indo-Chine 5 (1910) 68, Candollea 1 (1923) 71.

Plant fasciculate; the stem erect, suffrutescent, glabrous, 27 to 41 cm high, about 3 mm in diameter, simple and sparingly branched; the branches terete, glabrous, somewhat succulent. Leaves membranaceous, oblong-ovate to ovate, 7 to 13.5 cm long, 4 to 6 cm wide, base subequilaterally cordate, 5-nerved, apex acutely acuminate, brown-punctulate beneath, glabrous on

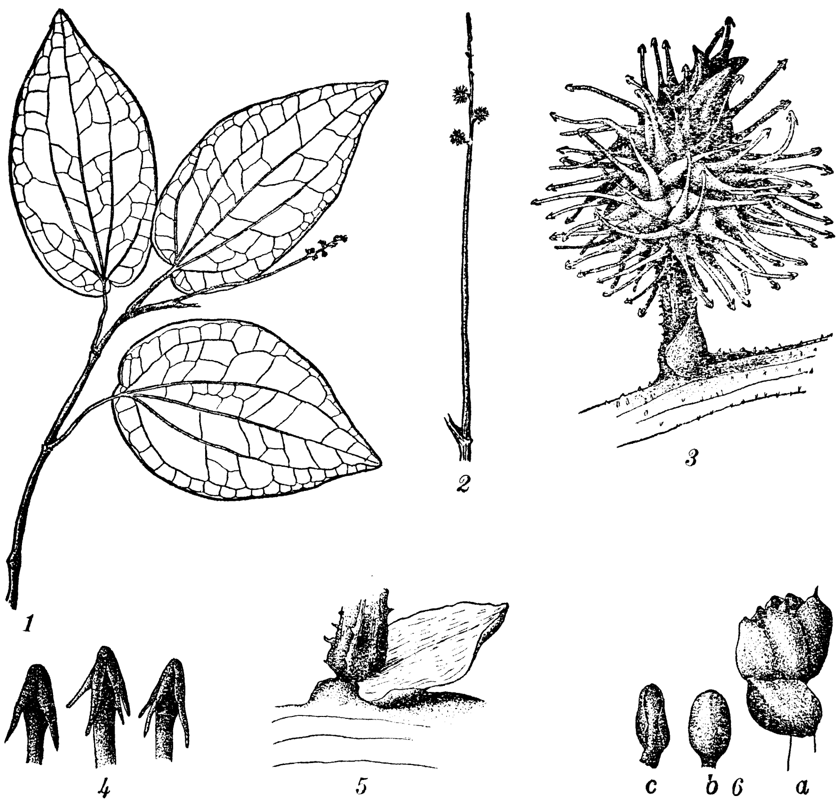


FIG. 103. *Piper begoniaefolium* (Blume) comb. nov.; *1*, fruiting branch, with young spike, × 0.5; *2*, mature spike, × 0.5; *3*, fruit, × 7.5; *4*, tips of bristles, × 40; *5*, bract adnate to the base of the pedicel, × 10; *6*, *a*, stamens and bract, *b*, front view of stamen; *c*, back view of stamen, × 10.

both surfaces; petioles glabrous, 1.6 to 2.7 cm long. Spike erect, solitary, leaf-opposed, 3 to 5 cm long; the peduncles glabrous, 7 to 11.5 cm long; rachis subglabrous to hirtellous, very slender, 0.5 to 0.75 mm in diameter; flowers small, bisexual, remote, inserted above the bracts; bracts sessile, base adnate to the rachis, disk membranaceous, ovate, cucullate, 1.25 to 1.5 mm long, 1 to 1.25 mm wide; ovary subglobose; stigmas 4, coalesced when young, separating at maturity, linear-ovoid; fruits pedicellate, glochidiate, remote, globose, 4 to 6 mm long, 4 to 5.5 mm in diameter including the bristles, the pedicels 1.25 to 2 mm long; stamens 6, anthers oblong to oblong-ovoid, erect, bilocular, dehiscence introrse, filaments very much shorter than the anthers.

JOLO, *Clemens 9335*, in damp forests, altitude about 700 meters. Indo-China and the Malay Peninsula to Sumatra and Borneo. Type from Java.

I do not agree with C. de Candolle in placing this in the section *Ottonia;* first by its morphologic features and secondly on account of its geographic range. None of the species in the section *Ottonia* have glochidiate fruits and 6 stamens. It is hardly conceivable that a group typically Indo-Malaysian will reach as far as Mexico and Brazil. This species has peculiar features not found in other representatives of the genus, notably the glochidiate fruits.

DOUBTFUL AND EXCLUDED SPECIES

PIPER AMBOINENSE C. DC.

> *Piper amboinense* C. DC., Prodr. 16^1 (1869) 347, Candollea 1 (1923) 190; F.-VILL., Novis. App. (1880) 175; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

"Hab. Luzon" F.-Villar. An Amboina species erroneously credited by F.-Villar to the Philippines. Amboina and Ternate.

It is very probable that F.-Villar saw a *Piper lessertianum* (Miq.) C. DC.

PIPER ARCUATUM Blume.

> *Piper arcuatum* BLUME in Verh. Bat. Genoots. 11 (1826) 180, *f. 11;* C. DC., Prodr. 16^1 (1869) 360, Candollea 1 (1923) 194; F.-VILL., Novis. App. (1880) 175; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

"V. v. sp. in Luzon" F.-Villar. A species erroneously credited by F.-Villar to the Philippines. It has not been found in the Archipelago. Java, Ternate, Ceylon, Amboina, Borneo.

PIPER ATTENUATUM Wall.

Piper attenuatum Wall.; MIQ., Syst. Pip. (1843) 306, Nov. Act. Acad. Nat. Cur. 21 (1846) Suppl. 49, *t. 49;* C. DC., Prodr. 16[1] (1869) 363, Candollea 1 (1923) 219; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

"V. v. sp. in Luzon" F.-Villar. A species erroneously credited by F.-Villar to the Philippines. It has not been found in the Archipelago. India and Malaya. The specimen seen by F.-Villar was probably a *Piper interruptum* Opiz.

PIPER CALLOSUM Ruiz and Pavon.

Piper callosum RUIZ and Pavon in Fl. Peru 1 (1798) 34, *t. 53, f. a.;* PRESL, Rel. Haenk. 1 (1828) 152; C. DC., Prodr. 16[1] (1869) 260, Candollea 1 (1923) 80; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

"Hab. in insula Luzon" Presl; the record was apparently based on a Peruvian specimen erroneously localized as Philippine.

PIPER CALVIFOLIUM C. DC.

Piper calvifolium C. DC. in Philip. Journ. Sci. 11 (1916) Bot. 217, Candollea 1 (1923) 195; MERR., Enum. Philip. Fl. Pl. 2 (1923) 5.

LUZON (*Loher 6794 p. p.*). Endemic.

I have examined the material in the Kew Herbarium and it is *Piper ramosii* C. DC. The other sheet which is deposited in the Munich Herbarium is the type of *Piper calvifolium* C. DC.; of it I have seen only a photograph.

PIPER CLYPEATUM Wall.

Piper clypeatum Wall.; C. DC., Prodr. 16[1] (1869) 378, Candollea 1 (1923) 230; MIQ., Syst. Pip. (1843) 337, p. p.; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

This species was erroneously credited to the Philippines by F.-Villar; it has not been found in the Archipelago. Penang, Singapore.

PIPER DENUDATUM Opiz.

Piper denudatum OPIZ in Presl Rel. Haenk. 1 (1828) 158; C. DC., Prodr. 16[1] (1869) 377, Philip. Journ. Sci. 5 (1910) Bot. 444, Candollea 1 (1923) 204; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 8.

Rhyncholepis haenkeana MIQ., Syst. Pip. (1843) 284, Fl. Ind. Bat. 1[2] (1858–59) 449.

I have examined and studied critically the type which was kindly loaned to me by Dr. Malkovsky, of the Prague Herbarium

and I am convinced that there was a mixture. The leaves look like a broad-leafed *Piper toppingii* C. DC. The single pistillate spike was detached from the plant and placed in a pocket. I do not believe the spike belongs to this plant at all. C. de Candolle and Miquel failed to describe the bracts. The spike, which was immature, can safely be a *Piper nigrum* Linn., noting particularly the bracts and type of the fruits. Merrill [9] interpreted this species as a valid one and reduced such species as *P. albidirameum*. I believe his interpretation was erroneous.

PIPER GRANDE Vahl.

> *Piper grande* VAHL in Eclog. Amer. 2 (1798) 3, *t. 11*, Enum. 1 (1804) 321; OPIZ, Presl in Rel. Haenk. 1 (1828) 156; C. DC., Prodr. 16^1 (1869) 370, Candollea 1 (1923) 136; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

"Hab. in insula Luzon" Opiz. Vahl's species is an American form and one of doubtful status. Haenke's Luzon specimen was either erroneously localized or wrongly identified.

PIPER GUAHAMENSE C. DC.

> *Piper guahamense* C. DC., Prodr. 16^1 (1869) 336, Philip. Journ. Sci. 9 (1914) 71, Candollea 1 (1923) 173; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

A species erroneously credited by F.-Villar to the Philippines; it has not been found in the Archipelago. Guam.

PIPER JAGORI C. DC.

> *Piper jagori* C. DC., Prodr. 16^1 (1869) 358 (*jayeri*, sphalm); Philip. Journ. Sci. 5 (1910) Bot. 437, Candollea 1 (1923) 190; F.-VILL., Novis. App. (1880) 175; MERR., Enum. Philip. Fl. Pl. 2 (1923) 10.

LUZON (*Jagor 162*, type in herb. Berlin). Probably from the forests at low altitudes. Endemic. A species of doubtful status. I have not seen the type specimen.

PIPER LATUM H.B.K.

> *Piper latum* H.B.K. in Nov. Gen. (1815–25) 57; OPIZ, Presl in Rel. Haenk. 1 (1828) 159; C. DC., Prodr. 16^1 (1869) 245; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

"Hab. ad portum Sorsogon in insula Luzon" Opiz. The record was unquestionably based on an American specimen erroneously localized in the Haenke Malaspina Expedition collection.

[9] Enum. Philip. Fl. Pl. 2 (1923) 8.

PIPER LONGUM Linn.

Piper longum LINN., Sp. Pl. (1753) 29; C. DC. Prodr. 16[1] (1869) 355, Philip. Journ. Sci. 5 (1910) Bot. 423, Candollea 1 (1923) 183; F.-VILL., Novis. App. (1880) 175; MERR., Enum. Philip. Fl. Pl. 2 (1923) 11.

According to C. de Candolle there is in his herbarium a specimen collected in the Philippines with the collector unknown. I have examined his herbarium and have not seen this particular specimen. As this species is cultivated from Ceylon to Malaysia it is possible that it exists as a cultivated plant in some parts of the Philippines, but its status as a Philippine species remains doubtful because it has not appeared in the very extensive collections made in all parts of the Archipelago in the past twenty-eight years.

PIPER MANILLANUM Miq.

Piper manillanum MIQ., Syst. Pip. (1843) 339; C. DC., Prodr. 16[1] (1869) 378; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

"Habitat in insula Manila (*Gaudichand 15,* Dec. 1836 in herb. de Less.), in Singapore (Wallich List No. 6655b ex parte)" Miquel. The Philippine specimen was probably from Singapore or Penang rather from the Philippines. C. de Candolle considered this species a synonym of *Piper clypeatum* Wall.

PIPER MARGINATUM Jacq.

Piper marginatum JACQ. in Ic. Pl. Rar. 2 (1781–93) 2, *t. 215;* C. DC., 16[1] (1689) 245, Candollea 1 (1923) 82, 84; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 17.

"Vidi vivam, cultam ad Manilam, N. vernaculum, *Buyo de Anis*" F.-Villar. A species erroneously credited to the Philippines by F.-Villar. It has not been found in the Archipelago. Tropical America. The specimen seen by F.-Villar was probably a *Piper betle* Linn.

PIPER POTAMOGETONIFOLIUM Opiz.

Piper potamogetonifolium OPIZ in Presl Rel. Haenk. 1 (1828) 156; C. DC., Prodr. 16[1] (1869) 376, Candollea 1 (1923) 230; F.-VILL., Novis. App. (1880) 176; MERR., Philip. Journ. Sci. 9 (1914) Bot. 72, Enum. Philip. Fl. Pl. 2 (1923) 17.

A species originally described from Guam, as yet not found in the Philippines. It is one of the species erroneously credited to the Philippines by F.-Villar.

PIPER RADICANS Vahl.

Piper radicans VAHL, Enum. 1 (1804) 333; OPIZ in Presl Rel. Haenk. 1 (1828) 159; C. DC., Prodr. 16^1 (1869) 379, Candollea 1 (1923) 321; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

Merrill's interpretation of the species is probably correct: "Vahl's type was from the Isle of France; Opiz was doubtless in error in referring Haenke's Luzon specimen to this species."

PIPER RUFINERVE Opiz.

Piper rufinerve OPIZ in Presl Rel. Haenk. 1 (1828) 159; MIQ., Syst. Pip. (1843) 366; C. DC., Prodr. 16^1 (1869) 377, Philip. Journ. Sci. 5 (1910) Bot. 462; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

"Habitat in insula Luzon" Haenke. A species of doubtful status, known only from the original description.

PIPER SYLVESTRE Lam.

Piper sylvestre LAM., Ill. 1 (1791) 79; VAHL, Enum. 1 (1804) 326; C. DC., Prodr. 16^1 (1869) 361, Candollea 1 (1923) 215 (*silvestre*); F.-VILL., Novis. App. (1880) 175; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

"V. v. sp. in Luzon," F.-Villar. Lamarck's type material was from "Insula Franciae, Malabaria, Philippines." As currently interpreted this is an Indian species.

PIPER TAUMANUM C. DC.

Piper taumanum C. DC. in Perk. Frag. Fl. Philip. (1905) 159, Philip. Journ. Sci. 5 (1910) Bot. 462, Candollea 1 (1923) 281; MERR., Enum. Philip. Fl. Pl. 2 (1923) 15.

MINDANAO, Davao Province, *Warburg 14741*.

This species is of doubtful status, having been described from a sterile and apparently juvenile specimen.

Genus PEPEROMIA Ruiz and Pavon

Key to the species of Peperomia.

1. Leaves alternate.
  2. Lamina subpellucid to pellucid, glabrous on both surfaces.
    3. Stems procumbent; fruits verruculose, never striate-costulate.
      4. Spikes axillary and terminal, filiform; lamina (3 to 8 by 4.5 to 10 mm); petioles up to 4 mm long........................ 15. *P. exigua.*
      4. Spikes leaf-opposed and terminal, fleshy; lamina (10 to 18 by 10 to 19 mm); petioles up to 16 mm long........ 20. *P. lanaoensis.*
    3. Stems erect.
      4. Fruits striate-costulate; spikes filiform................. 14. *P. pellucida.*
      4. Fruits verruculose, never striate-costulate; spikes fleshly. 10. *P. merrillii.*

2. Lamina opaque.
  3. Lamina glabrous on both surfaces, margins and apex glabrous; spikes subfleshy to fleshly, elongated, 3.5 to 6.8 cm long.
    4. Lamina nerved; spikes loosely flowered; fruits brown.
      5. Spikes subfleshy; bracts orbicular; fruits sparingly verruculose. 8. *P. pellucidopunctulata.*
      5. Spikes fleshy; bracts suborbicular; fruits verruculose. 7. *P. laevifolia.*
    4. Lamina plinerved; spikes densely flowered; fruits black and verruculose .... 9. *P. agusanensis.*
  3. Lamina glabrous on both surfaces, margins and apex ciliate, ovate-lanceolate to elliptic-lanceolate; spikes filiform, short, 8 to 15 mm long; stigma single, entire .... 11. *P. negrosensis.*
  3. Lamina glabrous above, pubescent beneath, elliptic-lanceolate; spikes filiform, moderately long, 20 to 35 mm long; stigma penicillate. 13. *P. elmeri.*
  3. Lamina pubescent on both surfaces, oblong-elliptic to rounded-elliptic; spikes subfiliform, long, 25 to 45 mm long; stigma single, entire .... 21 *P. rivulorum.*

1. Leaves opposite or verticillate.
  2. Rachis glabrous.
    3. Plant and leaves dark-colored; spikes densely flowered; lamina densely pubescent on both surfaces .... 4. *P. copelandii.*
    3. Plant and leaves not dark-colored.
      4. Spikes filiform or subfleshy.
        5. Stem prostrate or procumbent.
          6. Lamina membranaceous, elliptic-lanceolate (13 to 25 by 7 to 10 mm), apex and base acute; spikes up to 4 cm long. 12. *P. mindorensis.*
          6. Lamina thin, membranaceous, oblong to obovate (4 to 8 by 3 to 6 mm), base subacute, apex obtuse to rounded; spikes up to 2 cm long .... 3. *P. canlaonensis.*
        5. Stem erect or decumbent at the base.
          6. Sparsely and dichotomously branched.
            7. Lamina more or less pubescent on both surfaces, membranaceous, oblong-elliptic to obovate; spikes up to 5 cm long. 2. *P. pallidibacca.*
            7. Lamina glabrous on both surfaces, membranaceous, elliptic-ovate; spikes up to 4.5 cm long. 6. *P. lagunaensis.*
          6. Profusely branched, branches opposite, densely hirtellous; lamina densely pubescent on both surfaces, membranaceous to chartaceous, usually elliptic-obovate.
            7. Spikes up to 5 cm long .... 5. *P. recurvata* var. *pilosior.*
            7. Spikes up to 10.5 cm long.... 5. *P. recurvata* var. *longispica.*
      4. Spikes fleshy.
        5. Lamina more or less pubescent on both surfaces, obovate to rounded-ovate, 14 to 25 by 11 to 20 mm; spikes up to 9.5 cm long; stigma a little below the apex, globose. 19. *P. rubrivenosa.*

5. Lamina densely pubescent on both surfaces.
   6. Bracts subsessile, up to 0.5 mm wide; spikes up to 5.5 cm long.
      7. Lamina usually elliptic-ovate, sometimes rounded-elliptic-ovate (usually 12 to 20 by 10 to 15 mm); stigma terminal, entire, globose .... 16. *P. marivelesana.*
      7. Lamina subrhomboid-elliptic to subobovate-elliptic (11 to 23 by 5 to 11 mm); stigma a little below the apex, penicillate .... 17. *P. tomentosa* var. *carnosa.*
   6. Bracts pedicellate, up to 1.25 mm wide; lamina subobovate-elliptic or oblanceolate (20 to 40 by 12 to 18 mm); spikes up to 7 cm long.. 18. *P. latibracteata.*

2. Rachis pubescent.
   3. Lamina glabrous on both surfaces, chartaceous to subcoriaceous when dry; profusely branched; spikes fleshy, up to 35 mm long. 1. *P. reflexa* var. *capensis.*
   3. Lamina puberulent above, glabrous beneath, chartaceous; sparingly branched; spikes subfleshy, up to 10 mm long. 1. *P. reflexa* var. *parvilimba.*

1. PEPEROMIA REFLEXA (Linn. f.) A. Dietr. var. CAPENSIS (Miq.) C. DC. Text fig. 104.

Peperomia reflexa (Linn. f.) A. Dietr. var. *capensis* (Miq.) C. DC., Prodr. 16^1 (1869) 451.

Peperomia reflexa A. Dietr. forma *capensis* MIQ., Syst. Pip. (1843) 169; C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 410; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Peperomia reflexa A. Dietr. forma *subsessilifolia* C. DC., Prodr. 16^1 (1869) 452, Philip. Journ. Sci. 5 (1910) Bot. 410; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Peperomia reflexa A. Dietr. var. *calcicola* C. DC., in Philip. Journ. Sci. 5 (1910) Bot. 410, Candollea 1 (1923) 301; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Stems several, decumbent and rooting below, angular-sulcate, shining, glabrous or very sparingly and obscurely pubescent above or sometimes at the nodes, 7 to 23 cm long, 1.25 to 2 mm in diameter, profusely branched, branching dichotomously or rarely trichotomously, the branches angular-sulcate, shining glabrous or very sparingly and obscurely pubescent. Leaves verticillate (ternate or quaternate), sometimes opposite below, oblong-subelliptic, obovate, ovate-elliptic or rounded-elliptic, 7 to 15 mm long, 5 to 10.5 mm wide, base subacute to acute, obscurely 3-nerved, apex obtuse to rounded, chartaceous to subcoriaceous when dry, thick and fleshy when living, opaque, glabrous and shining on both surfaces, pellucido-punctulate or fusco-punctulate on both surfaces, not reticulate; petioles hirtellous, very slender, 1 to 2 mm long. Spike erect, always solitary and terminal, subfleshy to fleshy, densely flowered, usually 10 to 20 mm long, sometimes up to 35 mm in length; peduncles

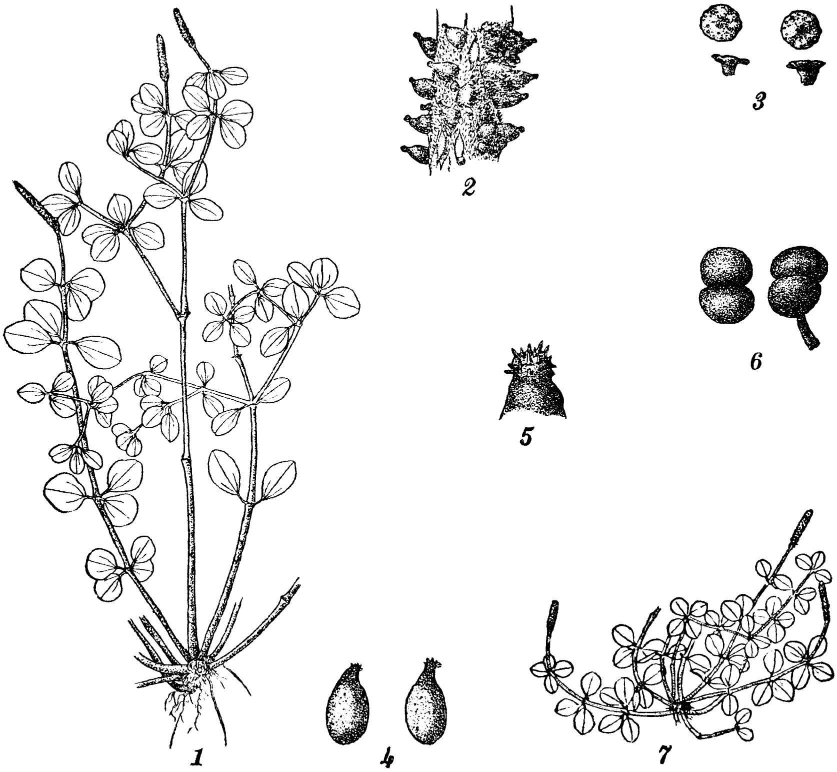


FIG. 104. *Peperomia reflexa* (Linn. f.) A. Dietr. var. *capensis* (Miq.) C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, portion of the spike, × 7.5; *3*, top and side views of bracts, × 10; *4*, fruits, × 10; *5*, detail of the apex of a fruit, × 40; *6*, stamens, × 40; var. *parvilimba* C. DC.; *7*, habit sketch of the plant, × 0.5.

hirtellous, slender, 10 to 21 mm long; rachis densely hirtellous, 1.5 to 2 mm in diameter; bracts subpedicellate, peltate, disk glabrous, membranaceous, orbicular, about 0.5 mm wide; stigma terminal or oblique, single, capitellate, puberulate-glandular; ovaries deeply immersed in deep pits, oblong, brown, smooth; fruits immersed in deep pits, oblong-cylindric, 0.8 to 1 mm long, 0.4 to 0.45 mm in diameter, acuminate, brown, smooth; stamens not numerous, deciduous after maturity, anthers ellipsoid, filaments longer than the anthers.

LUZON, Lepanto Subprovince, Mount Data, *Merrill 4583:* Benguet Subprovince, Baguio, *Elmer 6077* (type collection of *Peperomia reflexa* A. Dietr. var. *calcicola* C. DC.), *8576, Bur. Sci. 3480 Mearns, Sandkuhl 199, Williams 1114;* Mount Santo Tomas, *Bur. Sci. 5404 Ramos, For. Bur. 5066 Curran, 11105 Whitford, Philip. Pl. 748 Merrill;* Mount Pauai, *Bur. Sci. 8461*

McGregor; Mount Lusong, *Bur. Sci. 40442 Ramos and Edaño;* Mount Pulog, *Bur. Sci. 8894 McGregor, For. Bur. 16239 Curran, Merritt, and Zschokke.* MINDANAO, Bukidnon Province, Mount Candoon, *Bur. Sci. 38813 Ramos and Edaño:* Davao Province, Mount Apo, *Copeland s. n.* 1904. On trees, bowlders, and ledges at higher altitudes. In various forms and varieties in the Tropics of both hemispheres.

After critical study of all the Philippine specimens in the herbaria of the Bureau of Science, University of California, United States National Museum, and Kew, I find no justification in retaining var. *calcicola* C. DC. originally described from the Philippines. It differs from var. *capensis* only by the thickness of its leaves, which is apparently due to environmental conditions. I am also of the opinion that the Philippine specimens called *subsessilifolia* by C. de Candolle do not differ from *capensis.* Despite the variability of this species, I have only two cases in which the lower surface of the leaves are pubescent.

This remarkable species, very clearly distinct from any known *Peperomia* in the Philippines, is characterized by its pubescent rachis, and is readily recognized by its habit and foliage, its oblong-cylindric, smooth fruits which are immersed in deep pits, and its capitellate and puberulate-glandular stigma.

Var. PARVILIMBA C. DC.

Peperomia reflexa (Linn. f.) A. Dietr. var. *parvilimba* C. DC. in Candollea 1 (1923) 406, Philip. Journ. Sci. 5 (1910) Bot. 410 (forma *parvilimba* C. DC); MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Stem habit like *capensis*, glabrous, 4 to 6 cm high, 0.5 to 1 mm in diameter, very sparingly branched. Leaves ovate-elliptic to rounded-ovate, 4 to 7 mm long, 3 to 6.5 mm wide, base acute, obscurely 3-nerved, apex obtuse to rounded, chartaceous when dry, opaque, hirtellous above, glabrous beneath, apex and margins ciliate; petioles hirtellous, very slender, 0.75 to 1.5 mm long. Spike erect, solitary and terminal, subfleshy, densely flowered, 6 to 12 mm long; peduncles hirtellous, slender, 7 to 10 mm long; rachis densely hirtellous, somewhat fleshy, 1.25 to 1.5 mm in diameter; bracts, ovaries, stigmas, fruits, and stamens as in *capensis,* but somewhat smaller.

LUZON, Pampanga Province, Mount Arayat, *Merrill 3918* [type collection of *Peperomia reflexa* (Linn. f.) A. Dietr. var. *parvilimba* C. DC.], *Bolster 97.* On rocks near the summit. Endemic.

This variety, admirably represented by copious material of two collections, approaches most nearly var. *capensis* but is a

considerably smaller plant, with smaller leaves, which are pubescent on the upper surface. The spikes and peduncles are relatively shorter.

2. PEPEROMIA PALLIDIBACCA C. DC. Text fig. 105.

Peperomia pallidibacca C. DC. in Leafl. Philip. Bot. 3 (1910) 763, Philip. Journn. Sci. 5 (1910) Bot. 413, Candollea 1 (1923) 335; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Peperomia ramosii C. DC. in Candollea 1 (1923) 315 *nomen nudum*, 2 (1925) 188.

Stem erect with decumbent base, pale, glabrous to densely hirtellous, rather slender, rooting at the nodes, dichotomously branched, the branches subglabrous to densely hirtellous at the

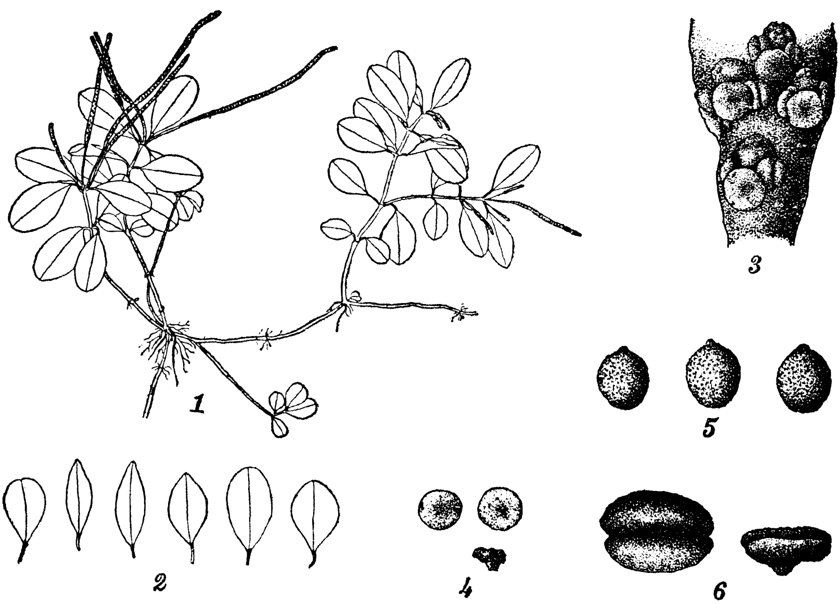


FIG. 105. *Peperomia pallidibacca* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, form of leaves, × 0.5; *3*, base of an immature spike, × 10; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

apices. Leaves opposite or ternate, oblong-elliptic to obovate, 10 to 20 mm long, 4 to 10 mm wide, rarely up to 25 mm in length, base cuneate, obscurely 3-nerved, apex subacute to rounded, pale, membranaceous, opaque, subglabrous on both surfaces, or glabrous above and puberulent beneath or hirtellous on both surfaces, apex ciliate, minutely pellucido-punctulate above, fusco-punctulate beneath; petioles hirtellous, very slender, 2 to 5 mm long. Spikes solitary to 5-nate, usually terminal, rarely axillary, filiform, subdensely flowered, pale, 2 to 5 cm

long; the peduncles subglabrous to hirtellous, 5 to 14 mm long; rachis glabrous, very slender, 0.75 to 1 mm in diameter; bracts subsessile, peltate, disk luteo-punctulate, orbicular, about 0.5 mm wide; ovaries immersed in pits, oblong-obovoid; stigma terminal, entire, glabrous; fruits with the bases partly immersed in pits, verruculose, oblong-obovoid, 0.75 to 0.8 mm long, 0.5 to 0.65 mm in diameter, light brown to brown; stamens subsessile, anthers ellipsoid.

LUZON, Bontoc Subprovince, Pinggat, *Vanoverbergh 488:* Benguet Subprovince, Mount Tonglon, *Merrill 7709;* Baguio, *Elmer 9344* (type collection of *Peperomia pallidibacca* C. DC.), *Pond s. n.* 1904: Rizal Province, San Isidro, *Bur. Sci. 12113 Ramos* (type collection of *Peperomia ramosii* C. DC.); Mount Lumutan, *Bur. Sci. 29619 Ramos and Edaño;* Montalban, *Loher 13137;* without definite locality, *Loher s. n.* 1913. At higher altitudes. Endemic.

This species is, I believe, allied to *Peperomia ventenatii* Miq. of Java, from which it is at once distinguished by its longer spikes, its orbicular bracts, oblong-obovoid fruits, and glabrous stigma.

3. PEPEROMIA CANLAONENSIS C. DC. Text fig. 106.

Peperomia canlaonensis C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 408, Candollea 1 (1923) 315; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

Stem prostrate, pale, pilose, slender, about 1 mm in diameter, rooting at the nodes, branching from the creeping stem, occasionally branching above, the branches pilose, very slender, 0.5 to 1 mm in diameter. Leaves usually opposite or ternate, or quaternate above, oblong to obovate, usually 4 to 8 mm long, 3 to 6 mm wide, very rarely up to 11 mm in length, base subacute, 1-nerved, apex obtuse to rounded, thin, membranaceous, opaque, sparsely pilose on both surfaces, densely pubescent on the midrib beneath, apex ciliate, margins glabrous, reticulations obsolete; petioles pilose, very slender, 2 to 4 mm long. Spike erect, solitary, terminal, filiform, subdensely flowered, usually 1 to 2 cm long, brown; peduncles pilose, very slender, 10 to 20 mm long; rachis glabrous, very slender, 0.75 to 1 mm in diameter; bracts subsessile, peltate, disk orbicular, about 0.5 mm wide; ovaries immersed, ovoid; stigma terminal, penicillate; fruits verruculose, brown, subglobose, 0.8 to 1 mm long, 0.6 to 0.75 mm in diameter, apex mucronulate, stamens pedicellate, anthers ellipsoid, filaments longer than the anthers.

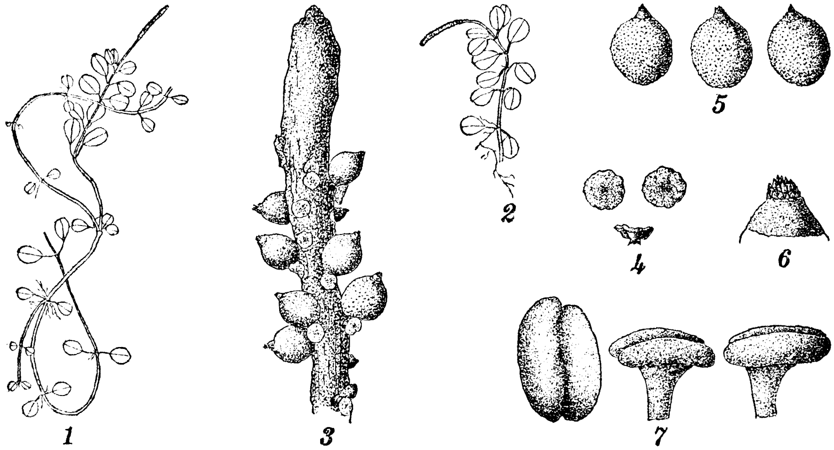


FIG. 106. *Peperomia canlaonensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, portion of the spike, × 7.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, apex of a fruit, × 40; *7*, stamens, top and side views, × 40.

NEGROS, Mount Canlaon, *Philip. Pl. 251 Merrill* (type collection of *Peperomia canlaonensis* C. DC.), on trees in the mossy forest, altitude about 1,800 meters. Endemic.

A species manifestly allied to *Peperomia ventenatii* Miq., but with distinctly smaller, solitary spikes, mucronulate fruits, and penicillate stigmas.

4. PEPEROMIA COPELANDII sp. nov. Text fig. 107.

Herba erecta vel procumbente, dense pubescente, nigrescente. Foliis oppositis, rotundato-obovatis, 7 ad 15 mm longis, 6.5 ad 8 mm latis, basi acutis, 1-nerviis, apice obtusis ad rotundatis, nigrescentibus, chartaceis, utrinque dense hirtellis; petiolis dense hirtellis, 1.5 ad 2 mm longis. Spicis erectis, solitariis vel binis, terminalibus, subfiliformibus, densifloris, 3 ad 3.5 cm longis; pedunculis hirtellis, 6 ad 8 mm longis; rachis glabris, 1 ad 1.25 mm diametro; bracteis subsessilibus, peltatis, peltis orbicularis, circiter 0.5 mm latis; ovario immerso, oblongo-obovoideo; stigmatibus punctiformis, obliquis, glabris; baccis immersis, oblongo-ovoideis, verruculosis, nigrescentibus, circiter 0.6 mm longis, 0.5 mm diametro, apice subacutis; staminibus pedicellatis, antheris ellipsoideo-subovoideis.

Stem erect or procumbent, dark-colored, densely hirtellous, somewhat slender, 6.5 to 7.5 cm high including the spikes, rooting below, branching very sparingly at the base; the branches hirtellous. Leaves opposite or ternate above, chartaceous,

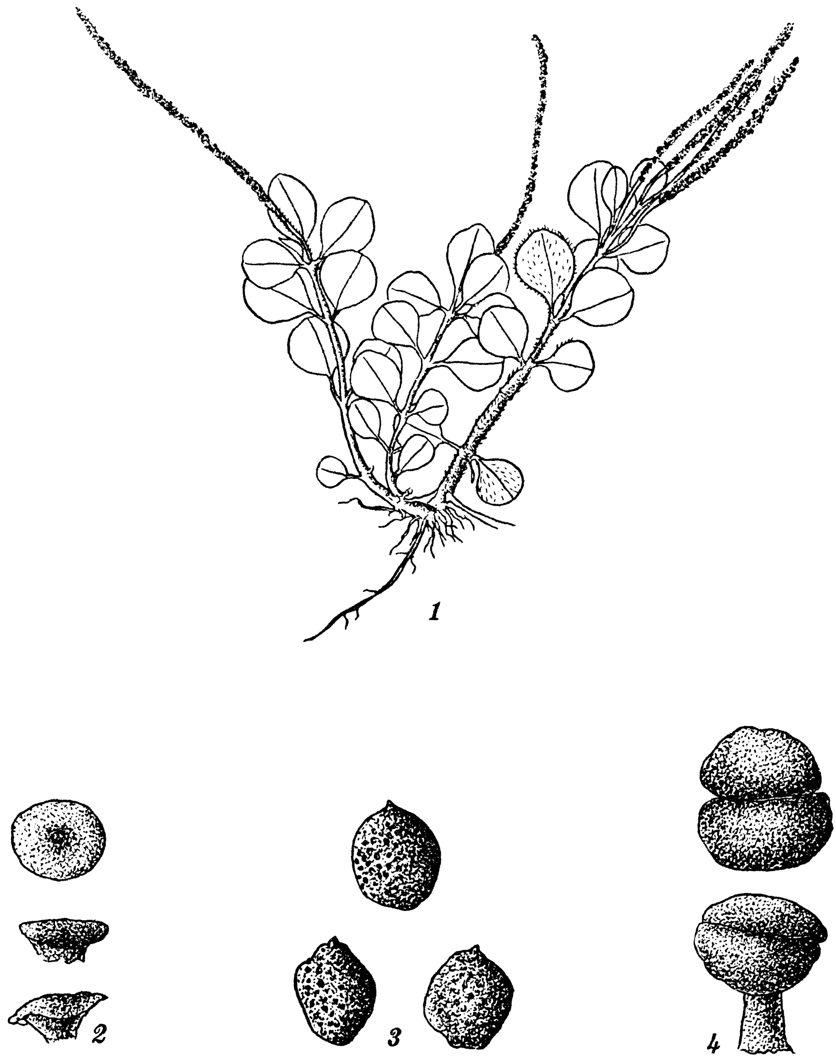


FIG. 107. *Peperomia copelandii* sp. nov.; *1*, habit sketch of the plant, × 1; *2*, top and side views of the bracts, × 20; *3*, fruits in different views, × 20; *4*, top and side views of stamens, × 80.

rounded-obovate, 7 to 15 mm long, 6.5 to 8 mm wide, base acute, 1-nerved, apex obtuse to rounded, dark-colored, opaque, densely hirtellous on both surfaces, margins and apex densely ciliate; petioles densely hirtellous, very slender, 1.5 to 2 mm long, in the lower leaves slightly longer, up to 3.5 mm in length. Spike erect, solitary or binate, terminal, subfiliform, densely flowered,

dark-colored, 3 to 3.5 cm long; the peduncles hirtellous, slender, 6 to 8 mm long; rachis glabrous, slender, 1 to 1.25 mm in diameter; bracts subsessile, peltate, disk orbicular, about 0.5 mm wide; ovaries immersed, oblong-obovoid; stigma entire, punctiform, oblique, glabrous; fruits oblong-ovoid, verruculose, black, about 0.6 mm long, 0.5 mm in diameter, apex subacute; stamens pedicellate, anthers ellipsoid-subovoid, filaments about as long as the anthers.

LUZON, Benguet Subprovince, Mount Pauai, *Copeland 178* (type in herb. Manila), May 1913, at higher altitudes.

This species is clearly a near relative of *Peperomia ventenatii* Miq., but differs in being dark-colored and its leaves being densely pubescent on both surfaces, and its glabrous, punctiform, oblique stigmas.

5. PEPEROMIA RECURVATA (Blume) Miq. var. PILOSIOR C. DC. Text fig. 108, 1-6.

Peperomia recurvata (Blume) Miq. var. *pilosior* C. DC. in Candollea 1 (1923) 406, Philip. Journ. Sci. 5 (1910) Bot. 409 (forma *pilosior* C. DC.); MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Stem erect, with decumbent base, densely hirtellous, fleshy, 15 to 20 cm high, 2 to 5 mm in diameter below, internodes below as short as 3 mm, lower ones rooting, profusely branched, the branches densely hirtellous, opposite, up to 2 mm in diameter. Leaves opposite or ternate, elliptic-ovate to elliptic-obovate, 15 to 32 mm long, 10 to 20 mm wide, base acute, 3-nerved, apex subacute to obtuse, membranaceous to chartaceous, opaque, densely hirtellous on both surfaces, apex and margins densely ciliate; petioles densely hirtellous, slender, 3 to 5 mm long. Spikes erect, terminal and axillary, usually binate to quaternate, very rarely solitary, filiform, densely flowered, 3 to 5 cm long; the peduncles densely hirtellous, 5 to 10 mm long; rachis glabrous, 0.75 to 1 mm in diameter; bracts subsessile, peltate, disk membranaceous, suborbicular to orbicular, 0.5 to 0.75 mm wide, glabrous; ovaries immersed, obovoid; stigma terminal, entire, glabrous; fruits subverruculose, brown, ovoid, about 0.75 mm long, 0.6 mm in diameter; stamens pedicellate, anthers minutely glandular, ellipsoid, filaments slightly shorter or as long as the anthers.

LUZON, Lepanto Subprovince, Banaao, *Vanoverbergh 603:* Benguet Subprovince, Baguio, *Elmer 6622* [type of *Peperomia recurvata* (Blume) Miq. var. *pilosior* C. DC. in herb. Manila], *Bur. Sci. 3501 Mearns.* On rocks at higher altitudes. Endemic.

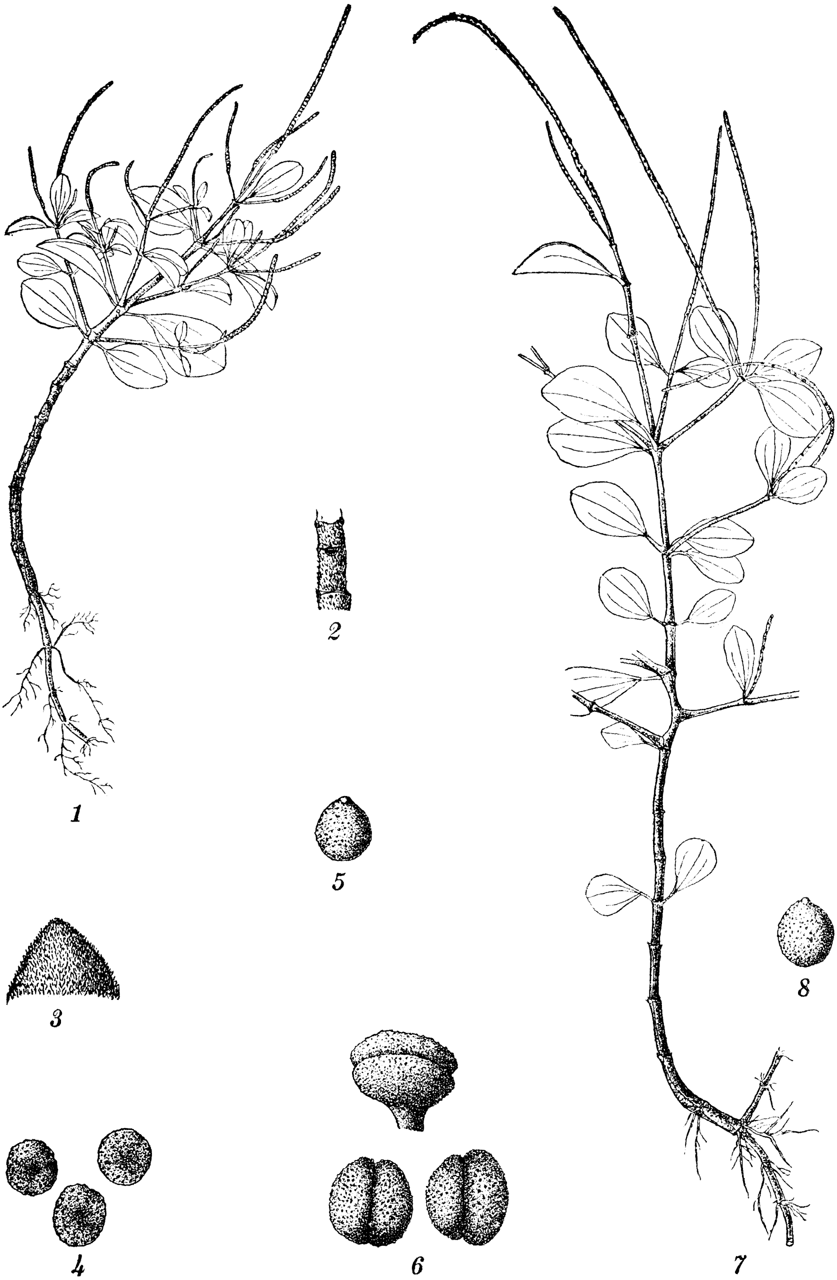


FIG. 108. *Peperomia recurvata* (Blume) Miq. var. *pilosior* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, stem, × 1.5; *3*, apex of a leaf, × 1; *4*, top view of bracts, × 10; *5*, fruit, × 10; *6*, side and top views of stamens, × 40; var. *longispica* C. DC.; *7*, habit sketch of the plant, × 0.5; *8*, fruit, × 10.

5. **PEPEROMIA RECURVATA (Blume) Miq. var LONGISPICA C. DC.** Text fig. 108, 7–8.

Peperomia recurvata (Blume) Miq. var. *longispica* C. DC. in Candollea 1 (1923) 321, Philip. Journ. Sci. 5 (1910) Bot. 409 (forma *longispica* C. DC.); MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Peperomia vanoverberghii C. DC. in Candollea 1 (1923) 321 *nomen nudum*, 2 (1925) 188.

Stem erect, with decumbent base, rarely prostrate, densely hirtellous, fleshy, 18 to 35 cm high, internodes a little longer than in var. *pilosior*, rooting below, profusely branched, the branches densely hirtellous, opposite or alternate, longer than in var. *pilosior*. Leaves opposite or ternate, elliptic-ovate to elliptic-obovate, 18 to 30 cm long, 9 to 17 mm wide, rarely up to 45 cm long and 27 mm wide, base acute, 3-nerved, apex acute to obtuse, membranaceous to chartaceous, opaque, densely hirtellous on both surfaces, apex and margins densely ciliate; petioles densely hirtellous, 3 to 8 mm long, rarely up to 12 mm in length. Spikes erect, spreading, solitary to quaternate, terminal and axillary, filiform, loosely flowered, 4.5 to 10.5 cm long; the peduncles densely hirtellous, 5 to 13 mm long; rachis glabrous, very slender, 0.5 to 1 mm in diameter; bracts subsessile, peltate, disk glabrous, suborbicular to orbicular, 0.5 to 0.75 mm wide; ovaries immersed, obovoid; stigma terminal, entire, glabrous; fruits oblong to ovoid-globose, about 0.75 mm long, 0.6 mm in diameter, verruculose, brown; stamens pedicellate, anthers minutely glandular, ellipsoid, filaments as long as the anthers.

LUZON, Lepanto Subprovince, Bauko, *Vanoverbergh 835, 1363;* without definite locality, *Vanoverbergh 603bis* (type of *Peperomia vanoverberghii* C. DC. in herb. de Candolle; isotype in herb. Manila): Benguet Subprovince, Kabayan, *Merrill 4425* [type collection of *Peperomia recurvata* (Blume) Miq. var. *longispica* C. DC.]; Mount Pauai, *Bur. Sci. 31715 Santos;* Baguio, *Williams 1084, For. Bur. 4847 Curran, Merrill 7682.* On wet rocky banks and on trees at higher altitudes. Endemic.

Local name: N͠galon (Ig.).

The type locality of the species is Mount Gédé, Java. The two varieties are apparently endemic to the Philippines. They seem to stand near *Peperomia dindygulensis* Miq. forma *macilenta* Miq., differing in their shorter internodes and densely flowered spikes (var. *pilosior*) and their glabrous stigma. The striking features of these varieties are the short internodes at the base of the stem and the numerous opposite branches.

The variety *longispica* is much closer to *Peperomia dindygulensis* Miq. forma *macilenta* Miq. than variety *pilosior*. It differs from var. *pilosior* by its longer and loosely flowered spikes.

6. **PEPEROMIA LAGUNAENSIS C. DC. Text fig. 109.**

Peperomia lagunaensis C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 407, Candollea 1 (1923) 319; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Peperomia puberulifolia C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 407, Candollea 1 (1923) 334; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

A species with much the habit of *Peperomia pellucida* (Linn.) HBK., the stems erect, sometimes with decumbent base, usually 13 to 20 cm high, sometimes up to 36 cm high, subglabrous to sparsely puberulent, somewhat fleshy, 1.5 to 2 mm in diameter, rooting at the nodes below, dichotomously branched, the branches subglabrous to sparsely puberulent. Leaves opposite, very rarely alternate, rarely ternate above, usually elliptic-ovate, sometimes oblong-elliptic or elliptic-obovate, 1.5 to 3.5 cm long, 1 to 1.8 cm wide, base acute, 3-nerved, apex acute, pale when dry, membranaceous, opaque, glabrous on both surfaces, apex ciliate, margins glabrous to ciliate; petioles glabrous, slender, 3 to 6 mm long, up to 8 mm in length. Spike erect, solitary or binate, rarely ternate, terminal and axillary, filiform, subdensely flowered, 2 to 4.5 cm long; the peduncles glabrous, very slender, 7 to 13 mm long; rachis glabrous, very slender, 0.75 to 1 mm in diameter; bracts subsessile, peltate, disk membranaceous, subpellucid, orbicular, about 0.5 mm wide; ovaries immersed, obovoid; stigma terminal, minute, entire, glabrous; fruits ovoid-globose to globose, 0.75 to 0.8 mm long, 0.6 to 0.75 mm in diameter, verruculose, brown, apex acute; stamens pedicellate, anthers ellipsoid, filaments longer than the anthers.

LUZON, Bataan Province, Mount Mariveles, *Merrill 7616, Whitford 114:* Laguna Province, Mount Maquiling, *Merrill 5130* (type collection of *Peperomia lagunaensis* C. DC.), *Elmer 17633, Bur. Sci. 17310 Robinson and Brown;* Mount Banahao, *Bur. Sci. 2446 Foxworthy, 6047* (type of *Peperomia puberulifolia* C. DC. in herb. Manila), *6079, 9760, 9776, 9809 Robinson, 27936 Ocampo, Quisumbing 1281, 1335, Juliano 1083.* In damp forests on mossy earth, bowlders, and tree trunks at medium and higher altitudes, ascending to 1,700 meters. Endemic.

In some respects this species would seem to stand near *Peperomia pellucidopunctulata* C. DC., however, it has usually smaller

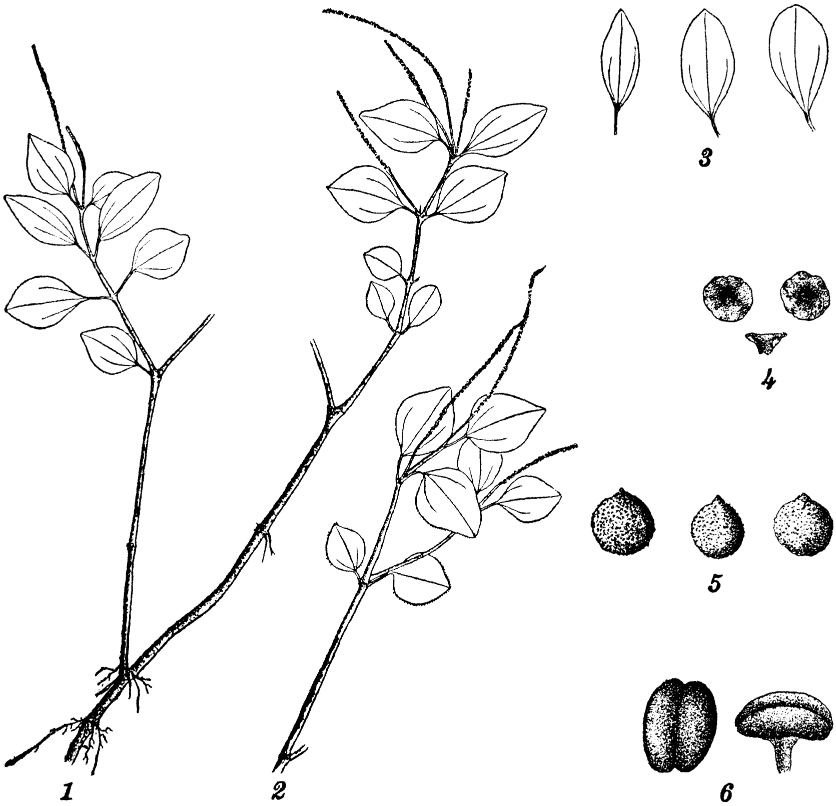


FIG. 109. *Peperomia lagunaensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, form of leaves, × 0.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

opposite leaves, sometimes ternate above, which are ciliate at the apex, filiform and shorter spikes, and pedicellate stamens.

7. PEPEROMIA LAEVIFOLIA (Blume) Miq. Text fig. 110.

Peperomia laevifolia (Blume) MIQ., Syst. Pip. (1843) 107; C. DC., Prodr. 16[1] (1869) 419, Candollea 1 (1923) 350, 356 *levifolia.*

Piper laevifolium BLUME in Cat. Gew. Buitenz. (1823) 33, Verh. Bat. Genoots. 11 (1826) 229.

Micropiper laevifolium MIQ., in Comment. Phyt. (1840) 56, *t. 9, f. E.*

Peperomia apoana C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 411, Candollea 1 (1923) 347; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

Stem erect, the base sometimes decumbent, glabrous, terete, 15 to 25 cm high, rooting below, dichotomously branched, the branches glabrous, terete, internodes rather short. Leaves alternate, oblong-elliptic to ovate, the lower ones obovate, 2.3 to

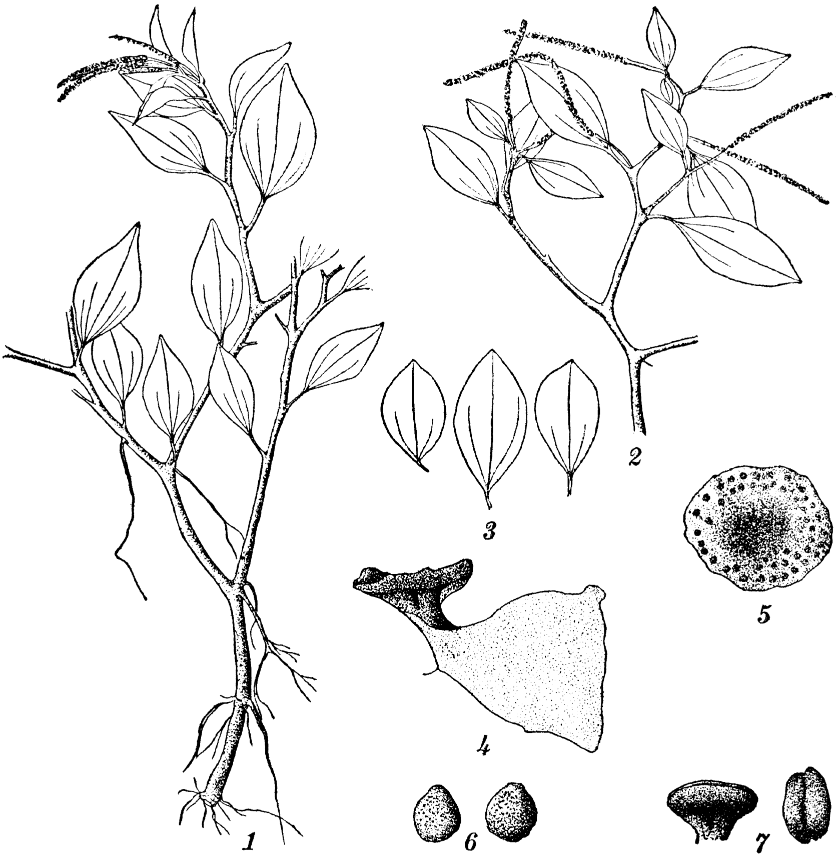


FIG. 110. *Peperomia laevifolia* (Blume) Miq.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, form of leaves, × 0.5; *4*, side view of ovary and bract, × 40; *5*, top view of bract, × 40; *6*, fruits, × 10; *7*, stamens, × 40.

4.2 cm long, 1 to 2.4 cm wide, base cuneate, 3-nerved to obscurely 5-nerved, apex acute to acutely subacuminate, membranaceous, opaque, somewhat rigid, glabrous on both surfaces, usually dark above, paler beneath, reticulations obsolete; petioles glabrous, 4 to 8 mm long, up to 15 mm in length. Spikes solitary to ternate, axillary and terminal, fleshy, loosely flowered, 3.5 to 4.5 cm long, up to 6 cm in length; the peduncles glabrous, usually 8 to 10 mm long, sometimes up to 20 mm in length; rachis glabrous, fleshy, 1.5 to 2 mm in diameter; bracts subpedicellate, peltate, disk glabrous, suborbicular, 0.4 to 0.6 mm wide; ovaries immersed, glabrous, ovoid; stigma terminal, entire, inconspicuous; fruits subglobose, 0.6 to 0.75 mm long, 0.5 to 0.6 mm in diameter, verruculose, brown; stamens subpedicellate, anthers ellipsoid, filaments about as long as the anthers.

PANAY, Antique Province, near Culasi, *Bur. Sci. 32441 McGregor.* NEGROS, Negros Oriental Province, Dumaguete, Cuernos Mountains, *Elmer 9970.* MINDANAO, Bukidnon Province, Mount Lipa, *Bur. Sci. 38560 Ramos and Edaño:* Davao Province, Mount Apo, *Copeland 1002* (type collection of *Peperomia apoana* C. DC.) : Zamboanga Province, Sax River Mountains, *Merrill 8158.* In forests at higher altitudes, ascending to 2,200 meters. Java.

Peperomia apoana C. DC. is certainly identical with *Peperomia laevifolia* (Blume) Miq., the type of which is from Java. This species differs from *Peperomia pellucidopunctulata* C. DC. conspicuously by being dichotomously branched, as well as in its suborbicular bracts, its verruculose fruits, and its numerous terminal spikes.

8. **PEPEROMIA PELLUCIDOPUNCTULATA C. DC.** Text fig. 111.

Peperomia pellucidopunctulata C. DC. in Leafl. Philip. Bot. 3 (1910) 760, Philip. Journ. Sci. 5 (1910) Bot. 411, Candollea 1 (1923) 349; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Stem erect, glabrous, subterete, 20 to 36 cm high, rooting at the base, usually branching sparingly from the base, the branches glabrous, subterete. Leaves alternate, oblong-elliptic to elliptic-lanceolate, 2.5 to 4.5 cm long, 1.4 to 2.2 cm wide, base acute, 5-nerved, apex acute to acutely acuminate, chartaceous, opaque, glabrous on both surfaces, margins and apex glabrous; petioles glabrous, 4.5 to 8 mm, sometimes up to 15 mm long. Spike usually solitary, very rarely binate, axillary and terminal, subfleshy, loosely flowered, 4.5 to 6.8 cm long; the peduncles glabrous, slender, 6 to 12 mm long; rachis glabrous, 1 to 1.5 mm in diameter; bracts subpedicellate, peltate, disk glabrous, orbicular, 0.4 to 0.5 mm wide; ovaries immersed, ovoid; stigma terminal, entire, more or less inconspicuous; fruits ovoid, 0.7 to 0.8 mm long, 0.5 to 0.6 mm in diameter, brown, sparingly verruculose; stamens subsessile, anthers ellipsoid.

LUZON, Benguet Subprovince, Baguio, *Elmer 8436* (type collection) : Albay Province, Mount Mayon, *Bur. Sci. 2962 Mearns, 6469 Robinson.* On rocks and tree trunks at medium and high altitudes. Endemic.

A species in some respects resembling *Peperomia merrillii* C. DC., but differing in its longer, subfleshy, loosely flowered spikes and its vegetative characters. The leaves are elliptic, opaque, densely pellucido-punctulate, and the first inner nerves fading out above the middle. The fruits are sparingly verruculose.

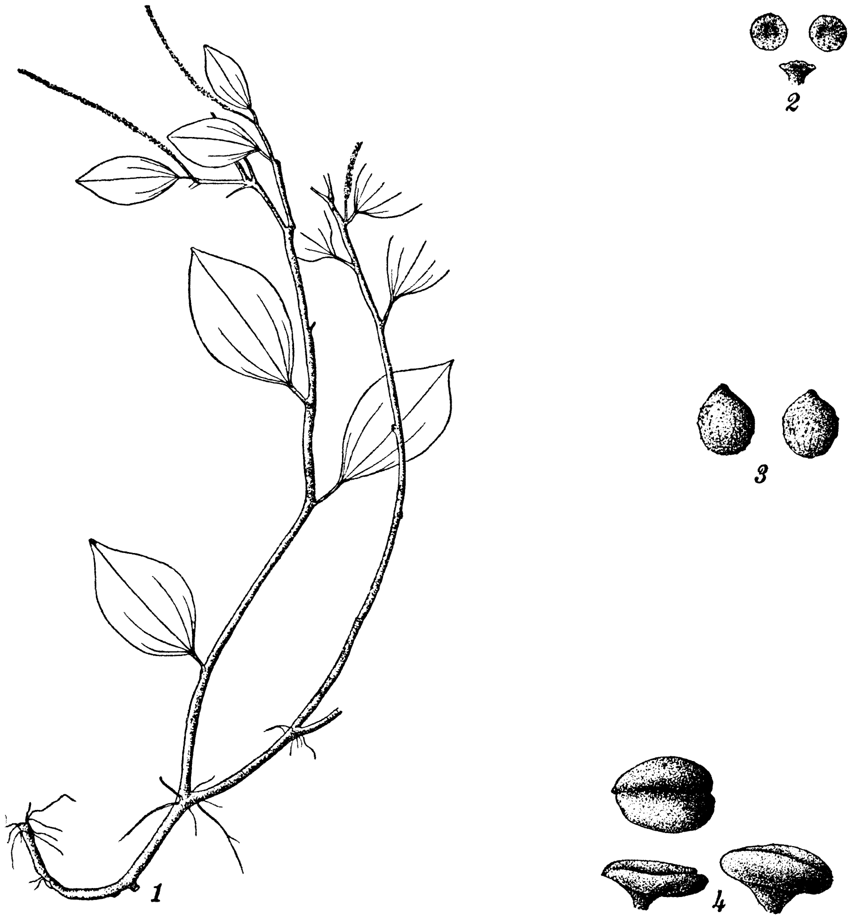


FIG. 111. *Peperomia pellucidopunctalata* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, top and side views of bracts, × 10; *3*, fruits, × 10; *4*, stamens, × 40.

9. PEPEROMIA AGUSANENSIS C. DC. Text fig. 112.

Peperomia agusanensis C. DC. in Leafl. Philip. Bot. 6 (1914) 2294, Candollea 1 (1923) 349; MERR., Enum. Philip. Fl. Pl. 2 (1923) 18.

Stem erect, glabrous, terete, 24 to 30 cm high, rooting below, dichotomously branched from the base, the branches glabrous, terete. Leaves alternate, oblong-elliptic, 2 to 4 cm long, 1.4 to 2.3 cm wide, base cuneate, 5- to 7-plinerved, apex acute to subacute, chartaceous, opaque, rigid, glabrous and nigro-punctulate on both surfaces, reticulations obsolete; petioles glabrous, usually 4 to 6 mm, sometimes 8 mm long. Spikes erect, usually binate, rarely solitary, axillary and terminal, subfleshy, densely

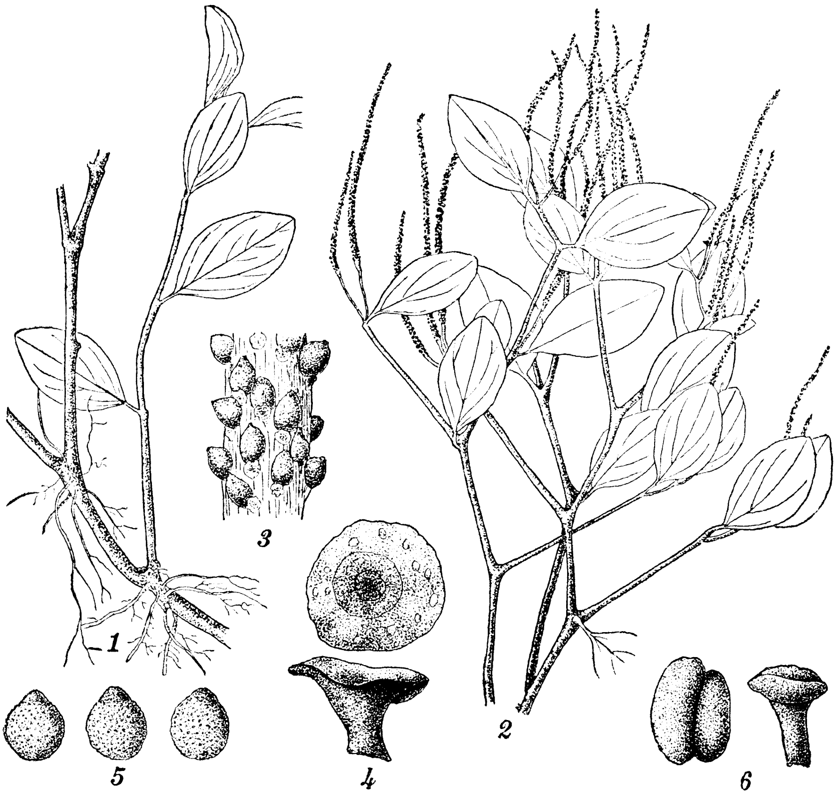


FIG. 112. *Peperomia agusanensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, part of main stem, × 0.5; *3*, portion of spike, × 7.5; *4*, top and side views of bracts, × 40; *5*, fruits, × 10; *6*, stamens, × 40.

flowered, 4.5 to 6 cm long; the peduncles glabrous, slender, 8 to 14 mm long; rachis glabrous, subfleshy, 1.25 to 1.5 mm in diameter; bracts subpedicellate, peltate, disk glabrous, orbicular, 0.4 to 0.5 mm wide; stigma terminal, entire, inconspicuous; fruits with the bases immersed in somewhat cupular depressions, ovoid, 0.6 to 0.75 mm long, 0.5 to 0.6 mm in diameter, verruculose, black; stamens pedicellate, anthers ellipsoid, filaments slightly longer than the anthers.

MINDANAO, Agusan Province, Cabadbaran, Mount Urdaneta, *Elmer 13625* (type collection). Endemic.

The alliance of this species is manifestly with *Peperomia laevifolia* (Blume) Miq. from which it is distinguished by its plinerved leaves, its densely flowered spikes, and its black fruits.

10. PEPEROMIA MERRILLII C. DC. Text fig. 113.

Peperomia merrillii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 411, Candollea 1 (1923) 341; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Stem erect, glabrous, 8 to 20 cm or even 30 cm high, rooting at the nodes near the base, branching sparingly throughout, the branches smooth, glabrous. Leaves alternate, elliptic-ovate to ovate, 2 to 3.5 cm or even 5.3 cm long, 1.5 to 2.5 or even 3.5 cm wide, base acute to rounded, 5-nerved, apex shortly and acutely to obtusely acuminate, membranaceous, subpellucid, glabrous on both surfaces, reticulations not distinct; petioles glabrous, 4.5 to 12 mm long, in the lower leaves up to 25 mm in length. Spike

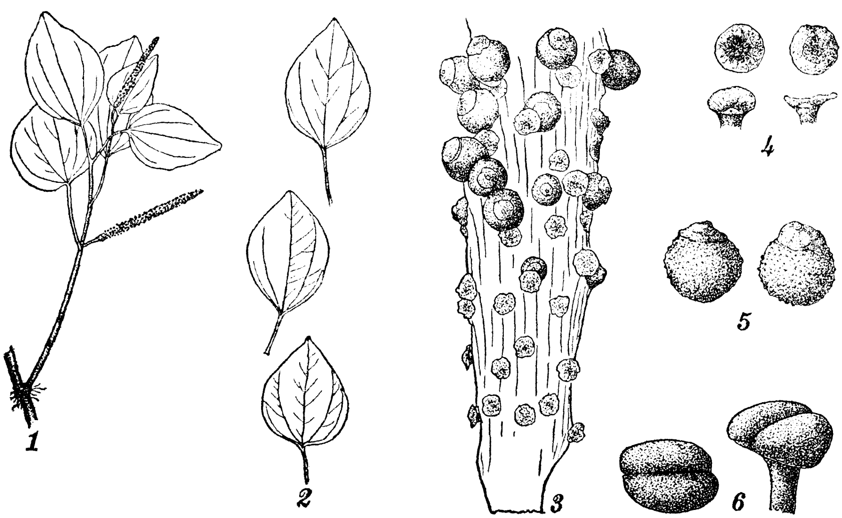


FIG. 113. *Peperomia merrillii* C. DC.; *1*, fruiting branch, × 0.5; *2*, form of leaves, × 0.5; *3*, lower portion of the spike, × 7.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

solitary, leaf-opposed and terminal, erect, fleshy, more or less densely flowered, 2 to 4.5 cm long; the peduncles glabrous, slender, 2.5 to 7 mm long; rachis glabrous, 1.75 to 3 mm in diameter; bracts subsessile, peltate, disk glabrous, thin, orbicular, 0.5 to 0.6 mm wide; ovaries immersed, ovoid; stigma terminal, more or less inconspicuous; fruits partly immersed in somewhat cupular depressions, globose, umbonate, 0.7 to 0.8 mm long, 0.6 to 0.75 mm in diameter, verruculose; stamens pedicellate, anthers oblong, dehiscence basal, introrse.

LUZON, Cavite Province, Maragondon, *Merrill 4180* (type collection): Rizal Province, Montalban, *Loher 4585;* Bosoboso, *For. Bur. 3359 Ahern's collector, Bur. Sci. 1071 Ramos;* Mount Canumay, *Bur. Sci. 13757 Ramos;* Mount Susong-dalaga, *Bur. Sci. 29319 Ramos and Edaño;* San Andales, *Bur. Sci. 48826 Edaño:* Laguna Province, Los Baños, Mount Maquiling, *Elmer 17800, 18414, For. Bur. 26750 Mabesa:* Sorsogon Province, Irosin, Mount Bulusan, *Elmer 15542, 16179.* On rocks at medium altitudes, ascending to 500 meters. Endemic.

A species certainly close to *Peperomia bilineata* (Blume) Miq., but differing essentially in its globose, verruculose fruits and its membranaceous, subpellucid leaves. It is further characterized by the umbonate apex of its fruits and the peculiar method of dehiscence of the anthers.

11. PEPEROMIA NEGROSENSIS C. DC. Text fig. 114.

Peperomia negrosensis C. DC. in Leafl. Philip. Bot. 3 (1910) 760, Philip. Journ. Sci. 5 (1910) Bot. 412, Candollea 1 (1923) 333; MERR., Enum. Philip. Fl. Pl. 2 (1923) 20.

Stem prostrate, puberulent, rooting at the nodes, branching irregularly, the branches puberulent. Leaves alternate, ovate-lanceolate to elliptic-lanceolate, usually 1.5 to 2.5 cm, sometimes up to 3.5 cm long, 0.7 to 1.4 cm, sometimes up to 2.1 cm wide, base acute, 3-nerved, apex acute, membranaceous, opaque, glabrous on both surfaces, margins and apex ciliate, reticulations not distinct; petioles puberulent, slender, 2 to 4 mm long. Spike erect, solitary or binate, leaf-opposed and terminal, filiform, loosely flowered, short, 8 to 15 mm long; the peduncles glabrous, very slender, 6 to 9 mm long; rachis glabrous, very slender, 0.5 to 0.75 mm in diameter; bracts sessile, peltate, disk glabrous, thin-membranaceous, orbicular, 0.4 to 0.5 mm wide; ovaries immersed, subglobose; stigma terminal, entire; fruits with bases partly immersed in somewhat cupular depressions, globose, 0.5 to 0.6 mm long, 0.5 to 0.6 mm in diameter; stamens pedicellate, anthers globose, filaments longer than the anthers.

NEGROS, Dumaguete, Cuernos Mountains, *Elmer 9425* (type collection), on mossy rocks in shaded ravines. Endemic.

The species is, I believe, allied to *Peperomia exigua* (Blume) Miq., from which it is distinguished by its habit of growth, its puberulent stems and branches and petioles, its ovate-lanceolate to elliptic-lanceolate, opaque leaves, which are ciliate at the margins and apex, and its globose fruits and anthers.

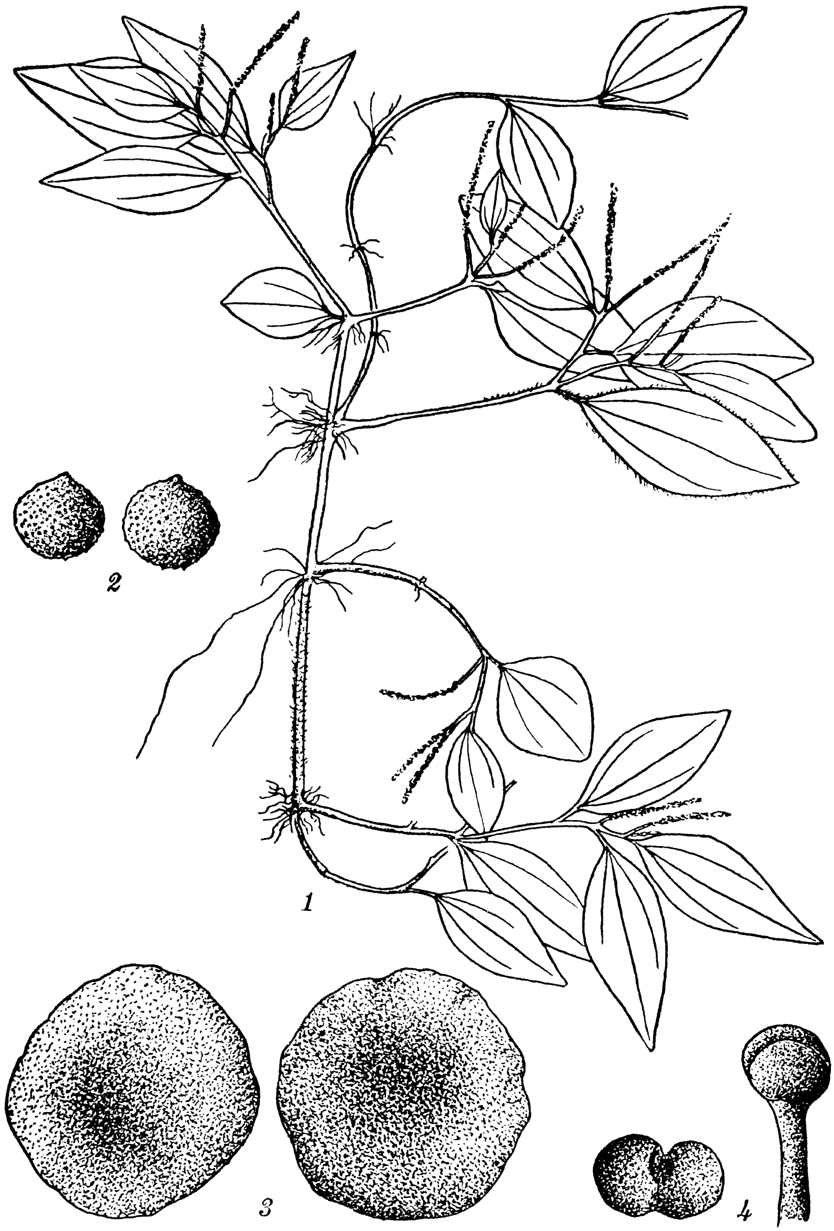


FIG. 114. *Peperomia negrosensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, fruits, × 20; *3*, top view of bracts, × 80; *4*, top views of stamens, × 80.

12. PEPEROMIA MINDORENSIS C. DC. Text fig. 115.

Peperomia mindorensis C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 413, Candollea 1 (1923) 358; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Stem prostrate or procumbent, pale, densely pubescent, slender, terete, rooting at the nodes, sparingly branched. Leaves opposite or ternate, elliptic-lanceolate, 13 to 25 mm long, 7 to 10 mm wide, base acute, 3-nerved, apex acute, pale when dry,

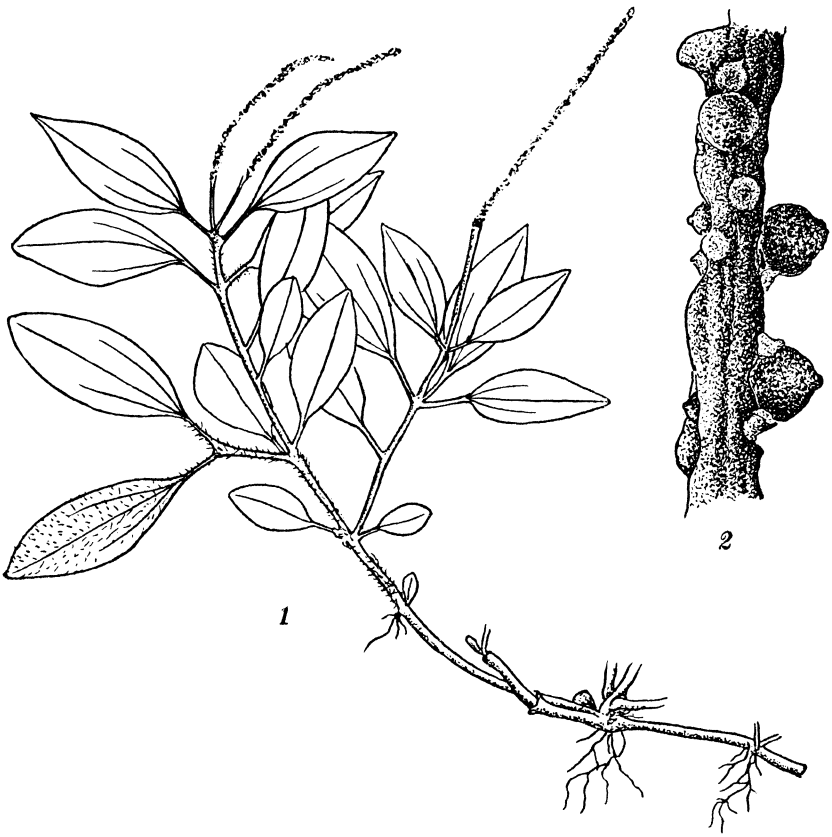


FIG. 115. *Peperomia mindorensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, portion of the spike, × 18.

membranaceous, opaque, densely pilose on both surfaces particularly the lower surface, fusco-punctulate beneath; petioles densely pubescent, very slender, 3 to 6 mm long. Spike solitary or binate, usually terminal, rarely axillary, filiform, subdensely flowered, pale when dry, 2 to 4 cm long; the peduncles densely pubescent, very slender, 6 to 9 mm long; rachis glabrous; bracts subsessile, peltate, disk orbicular, 0.6 to 0.75 mm wide; ovaries

immersed in pits; stigma terminal, entire, glabrous; fruits globose, verruculose, about 0.75 mm long, 0.6 mm in diameter, reddish brown; stamens pedicellate, anthers ellipsoid.

MINDORO, Mount Halcon, *Merrill 6107* (type collection), *6184*, on mossy trees, altitude about 1,500 meters. Endemic.

A species belonging in the group with *Peperomia pallidibacca* C. DC., differing in its habit of growth, its elliptic-lanceolate leaves, its globose fruits, and pedicellate stamens.

13. PEPEROMIA ELMERI C. DC. Text fig. 116.

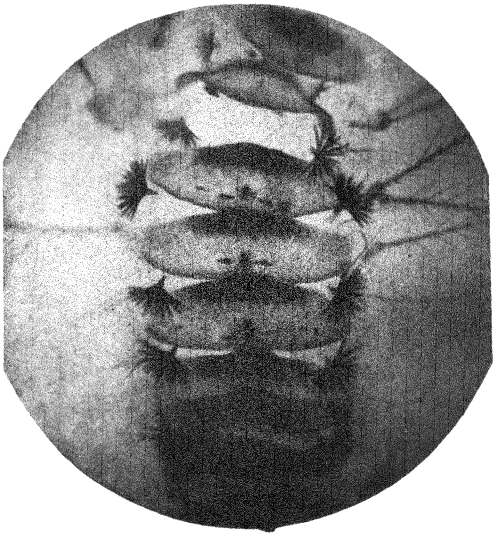
Peperomia elmeri C. DC. in Leafl. Philip. Bot. 3 (1910) 761, Philip. Journ. Sci. 5 (1910) Bot. 412, Candollea 1 (1923) 357; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Epiphytic, the stem weak, pendulous, 30 to 70 cm long, appressed-hirsute, rooting below, the roots reddish, the branches appressed-hirsute. Leaves alternate, remote, elliptic-lanceolate, 2.5 to 5 cm long, 0.8 to 1.5 cm wide, narrowed to the acute apex and base, 3-nerved, membranaceous, opaque, glabrous above, pilose beneath, the younger leaves pilose on both surfaces, margins glabrous, apex ciliate, reticulations not distinct; petioles pilose, slender, 4 to 7 mm, sometimes up to 10 mm long. Spike pendulous, solitary, axillary and terminal, filiform, loosely flowered, 2 to 3.5 cm long; the peduncles glabrous, very slender, 10 to 15 mm long; rachis glabrous, very slender, 0.5 to 0.75 mm in diameter; bracts subsessile, peltate, disk membranaceous, suborbicular to orbicular, 0.5 to 0.6 mm wide; ovaries immersed, ovoid; stigma terminal, penicillate, usually deciduous in mature fruits; fruits with bases partly immersed in somewhat cupular depressions, ovoid to globose, subacute, 0.75 to 0.8 mm long, 0.65 to 0.75 mm in diameter, conspicuously verruculose, dark brown; stamens pedicellate, anthers ellipsoid, filaments longer than the anthers.

MINDANAO, Davao Province, Mount Apo, *Elmer 10493* (type collection), on tree trunks, altitude about 1,200 meters. Endemic.

Local name: Salibútbut (Bag.).

A species characterized by its pendulous habit, its long, weak stems, its solitary, filiform spikes, and by its penicillate stigmas. It probably belongs in the group with *Peperomia negrosensis* C. DC., but is remote from that species.



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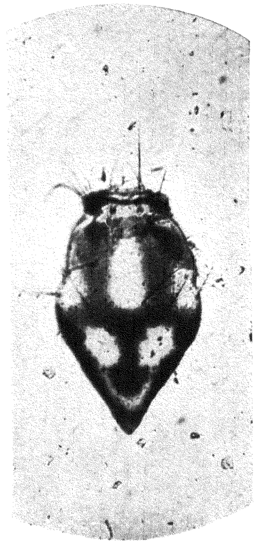

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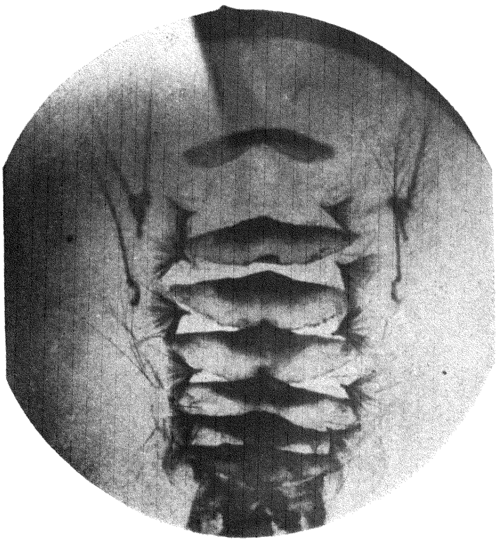

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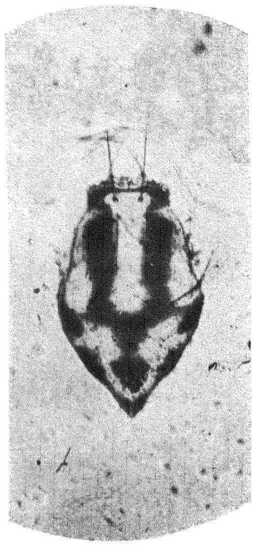

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PLATE 1.

14. PEPEROMIA PELLUCIDA (Linn.) HBK. Text fig. 117.

Peperomia pellucida (Linn.) HBK., Nov. Gen. Sp. Pl. 1 (1815) 64; MIQ., Syst. Pip. (1843) 79; C. DC., Prodr. 16^1 (1869) 402, Candollea 1 (1923) 341; MERR., Fl. Manila (1912) 170, Enum. Philip. Fl. Pl. 2 (1923) 20.

Piper pellucida LINN., Sp. Pl. (1753) 30, ed. 2 (1762) 42.

Micropiper pellucidum MIQ., Comment. Phyt. (1840) 54.

Peperomia hymenophylla MIQ., in Nov. Act. Acad. Nat. Cur. **19** (1843) Suppl. 1: 485, Syst. Pip. (1843) 78.

Micropiper tenellum KLOTZ. ex. Miq. Fl. Ind. Bat. 1^2 (1858–59) 432.

Stem erect, succulent, glabrous, terete, 20 to 33 cm high including the spikes, dichotomously branched, the branches smooth, terete, glabrous. Leaves alternate, broadly ovate to broadly heart-shaped, 1.4 to 2.8 cm long, 1.5 to 2.6 cm wide, base

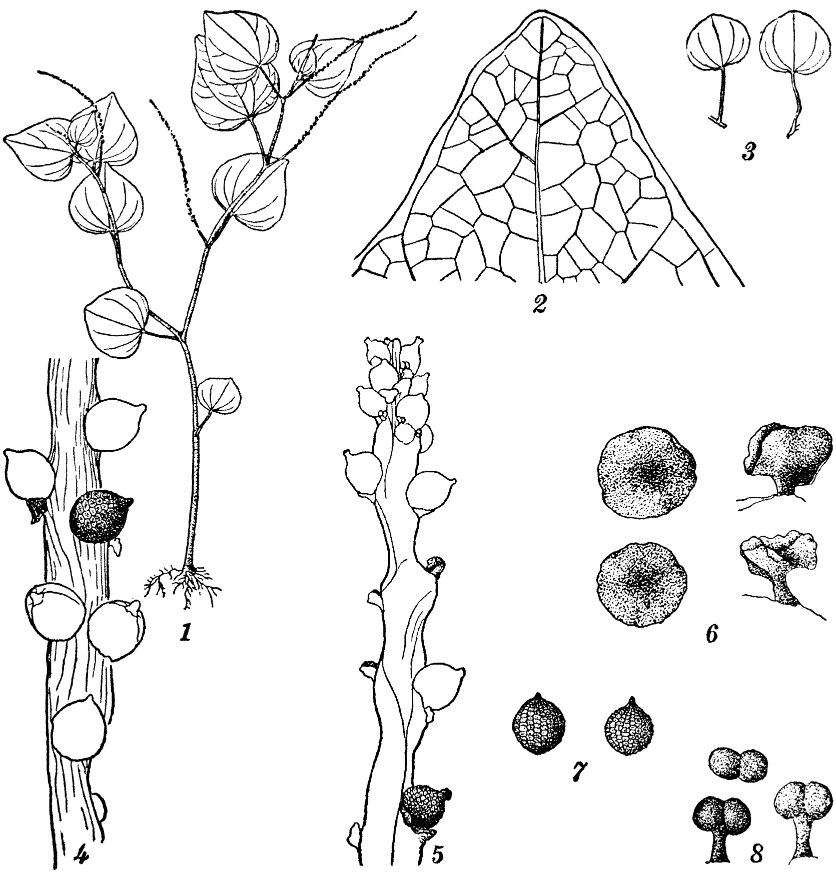

FIG. 117. *Peperomia pellucida* (Linn.) HBK.; *1*, habit sketch of the plant, × 0.5; *2*, apex of a leaf, × 7.5; *3*, form of leaves, × 0.5; *4*, lower portion of spike, × 10; *5*, apical portion of spike, × 10; *6*, top and side view of bracts, × 40; *7*, fruits, × 10; *8*, stamens, × 40.

usually subcordate to cordate, sometimes truncate, 5- to 7-nerved, apex shortly and obtusely acuminate, rarely rounded, thin-membranaceous, pellucid, glabrous on both surfaces, reticulations prominent; petioles glabrous, slender, 6 to 10 mm, sometimes up to 15 mm long. Spike solitary, leaf-opposed and terminal, erect, filiform, loosely flowered, 3 to 5 cm long; the peduncles glabrous, slender, shorter than the petioles, 2.5 to 5 mm long; rachis glabrous, slender; bracts subpedicellate, peltate, disk glabrous, thin-membranaceous, orbicular, 0.3 to 0.4 mm wide; stigma terminal, entire; fruits ellipsoid-ovoid to ovoid, rostellate, 0.6 to 0.8 mm long, 0.5 to 0.75 mm in diameter, striate-costulate, glabrous; stamens pedicellate, anthers reniform to oblong-subglobose, filaments shorter or about as long as anthers.

LUZON, Isabela Province, Mount Moises, *Clemens 16697:* La Union Province, San Fernando, *Lete 199*: Pampanga Province, Bacolor, *Parker 23:* Rizal Province, Tanay, *Bur. Sci. 11878 Robinson and Ramos;* Pasig, *Merrill 9785:* Manila, *Meyen s. n.*, Oct. 1831 (type of *Peperomia hymenophylla* Miq. in herb. Berlin), *Elmer 5511, Merrill 87, Reyes 35:* Laguna Province, Los Baños, *Holman 679, Coll. Agric. 19930 Robin.* A pantropic species of American origin, common in the rainy season on and about damp walls in towns and now widely distributed in the Philippines.

Local name: Olasíman-ihalas (C. Bis.).

A species characterized by its erect, succulent stems, its thin-membranaceous, pellucid, reticulate leaves, its elongated, filiform spikes, and its ellipsoid-ovoid to ovoid striate-costulate fruits.

15. PEPEROMIA EXIGUA (Blume) Miq. Text fig. 118.

Peperomia exigua (Blume) MIQ., Syst. Pip. (1843) 77, Nov. Act. Acad. Nat. Cur. **19** (1843) Suppl. **1**: 484, Fl. Ind. Bat. 1^2 (1858–59) 432; F.-VILL., Novis. App. (1880) 176; C. DC., Prodr. 16^1 (1869) 403, Leafl. Philip. Bot. **3** (1910) 759, Philip. Journ. Sci. **5** (1910) Bot. 410, Candollea **1** (1923) 328; MERR., Enum. Philip. Fl. Pl. **2** (1923) 19.

Piper exiguum BLUME, in Verh. Bat. Genoots. **11** (1826) 232, *f. 36.*

Micropiper exiguum MIQ., Comment. Phyt. (1840) 55, *t. 9, f. D.*

Stem procumbent, forming dense patches, very slender, rooting at the nodes, glabrous, terete, sparingly branched; the branches glabrous. Leaves alternate, rounded-ovate to broadly heart-shaped, 3 to 8 mm long, 4.5 to 10 mm wide, base truncate to cordate, 5-nerved, apex rounded, thin-membranaceous, subpellucid to pellucid, glabrous on both surfaces, reticulations distinct; petioles glabrous, very slender, 3 to 4 mm long. Spike

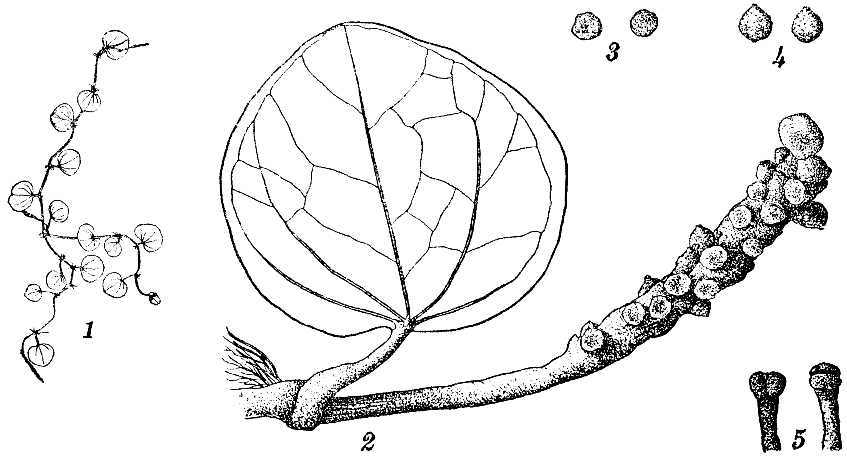

FIG. 118. *Peperomia exigua* (Blume) Miq.; *1*, habit sketch of the plant, × 0.5; *2*, leaf and spike, × 7.5; *3*, top view of bracts, × 10; *4*, fruits, × 10; *5*, stamens, × 40.

solitary, axillary and terminal, filiform, somewhat densely flowered, 6 to 11 mm long, 0.5 to 0.75 mm in diameter; the peduncles glabrous, very slender, 5 to 10 mm long; rachis glabrous; bracts sessile, peltate, disk pellucid, orbicular, 0.35 to 0.4 mm wide; ovaries immersed; stigma terminal, bilobed; fruits with bases partly immersed, ovoid, rostellate, 0.35 to 0.5 mm long, 0.3 to 0.45 mm in diameter, glabrous, verruculose; stamens pedicellate, anthers oblong, filaments longer than the anthers.

MINDANAO, Davao Province, Todaya, Mount Apo, *Elmer 11004*. Creeping and forming dense patches on wet ledges or cliffs, in dense woods along Baracatan Creek, at 500 meters altitude. Tropical America, India, and the Malayan Archipelago. The type was from Java.

Local name: Sigbat-ta-pangpang (Bag.).

This species is characterized by its very slender, procumbent stem, its small pellucid, alternate, rounded-ovate to broadly heart-shaped leaves, with rounded apices, its filiform, terminal and axillary spikes and ovoid, verruculose fruits.

16. PEPEROMIA MARIVELESANA C. DC. Text fig. 119.

Peperomia marivelesana C. DC. in Leafl. Philip. Bot. 3 (1910) 762, Philip. Journ. Sci. 5 (1910) Bot. 413, Candollea 1 (1923) 320, 358; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Stem prostrate or decumbent, hirsute, fleshy, usually 9 to 15 mm, sometimes up to 25 mm long, rooting below, sparingly and dichotomously branched, the branches hirsute. Leaves usually opposite, rarely ternate above, usually elliptic-ovate, sometimes

rounded-elliptic-ovate, usually 10 to 20 mm, sometimes up to 30 mm long, 10 to 15 mm, sometimes up to 21 mm wide, base acute, 3-nerved, apex obtuse, membranaceous, opaque, densely hirsute on both surfaces, apex and margins densely ciliate, reti-

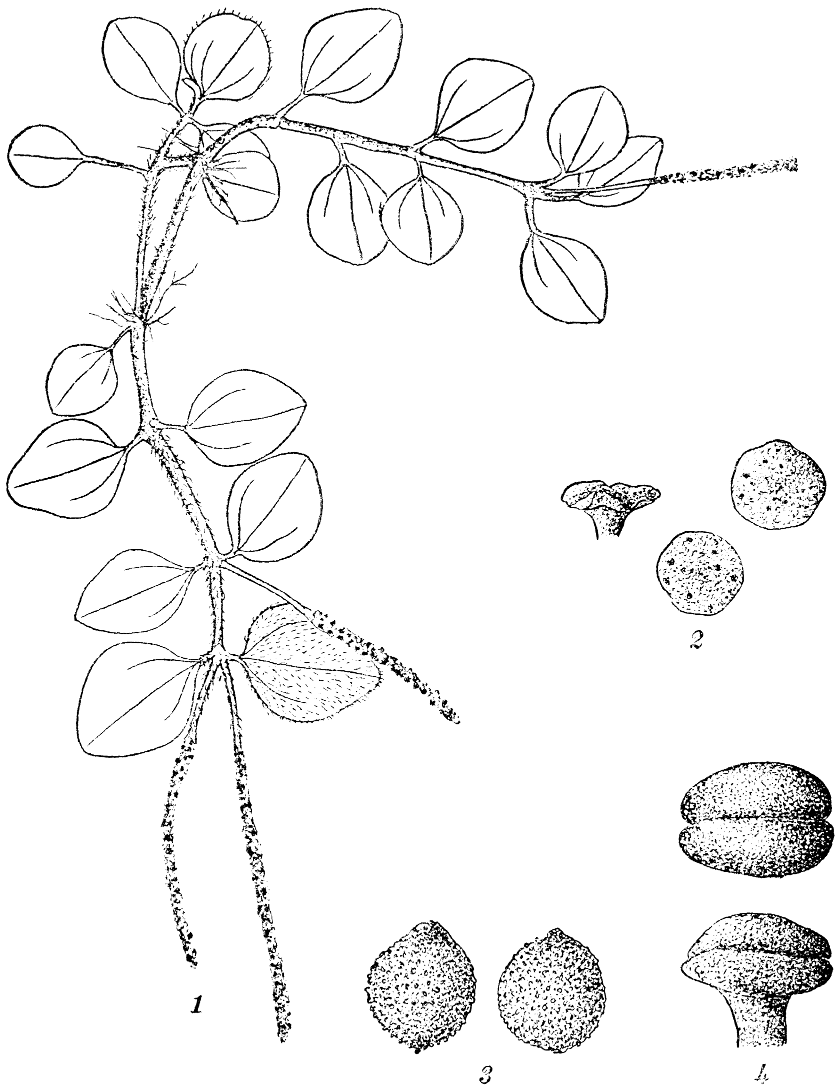

FIG. 119. *Peperomia marivelesana* C. DC.; *1*, habit sketch of the plant, × 1; *2*, side and top views of bracts, × 20; *3*, fruits, × 20; *4*, stamens, × 80.

culations obsolete; petioles densely hirsute, slender, usually 2.5 to 5 mm, very rarely up to 15 mm in length. Spikes erect, solitary or binate, terminal and axillary, fleshy, densely flowered, 3

to 5.5 cm long; the peduncles hirsute, slender, 10 to 15 mm long; rachis glabrous; bracts subsessile, peltate, disk glabrous, orbicular, about 0.5 mm wide; ovaries immersed, obovoid; stigma terminal, entire, globose, glabrous; fruits ovoid, 0.75 to 0.85 mm long, 0.6 to 0.75 mm in diameter, verruculose, brown; stamens pedicellate, anthers ellipsoid, filaments longer than the anthers.

LUZON, Ilocos Norte Province, Mount Nagapatan, *Bur. Sci. 33164 Ramos:* Nueva Viscaya Province, Caraballo Mountains, *De Veyra s. n.* 1916: Bataan Province, Mount Mariveles, *Merrill 3721* (type collection), *3205a, 7618, Bur. Sci. 6210a Robinson, Whitford 313, Elmer 6820:* Laguna Province, Mount Maquiling, *Elmer 17702.* MINDORO, Mount Halcon, *Merrill 6147.* PALAWAN, Mount Victoria, *Bur. Sci. 678 Foxworthy.* On mossy rocks and on tree trunks, at altitudes from 450 to 1,200 meters. Endemic.

This species is allied to *Peperomia rubrivenosa* C. DC. but differs in its leaves being densely pubescent on both surfaces, its terminal stigma, and its smooth anthers.

17. PEPEROMIA TOMENTOSA (Vahl) A. Dietr. var. CARNOSA Miq. Text fig. 120.

Peperomia tomentosa (Vahl) A. Dietr. var. *carnosa* MIQ., Syst. Pip. (1843) 143; C. DC., Prodr. 16^1 (1869) 455, Philip. Journ. Sci. 5 (1910) Bot. 409, Candollea 1 (1923) 320; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

Piper tomentosum Vahl var. *carnosum* BLUME in Verh. Bat. Genoots. 11 (1826) 233, *f. 41.*

Stem decumbent, ochraceo-tomentose, fleshy, 11.5 to 16 cm long, rooting below, very sparingly branched, the branches tomentose, opposite or alternate above. Leaves opposite or ternate, subrhomboid-elliptic to subobovate-elliptic, 11 to 23 mm long, 5 to 11 mm wide, base cuneate, 1-nerved, apex subacute to obtuse, chartaceous to subcoriaceous, opaque, ochraceo-tomentose on both surfaces, apex and margins densely ciliate; petioles tomentose, slender, usually 1.5 to 4.5 mm long. Spikes erect, usually binate to quinate, very rarely solitary, terminal and axillary, fleshy, densely flowered, 2 to 3.5 cm long; the peduncles ochraceo-tomentose, slender, 10 to 15 mm long; rachis glabrous; bracts subsessile, peltate, disk glabrous, fleshy, orbicular, about 0.4 mm wide; ovaries immersed, ovoid; stigma a little below the apex, penicillate; fruits with bases immersed in somewhat cupular depressions, ovoid, about 0.6 mm long, 0.5 mm in diameter, verruculose, black; stamens subpedicellate, anthers ellipsoid, filaments slightly longer than the anthers.

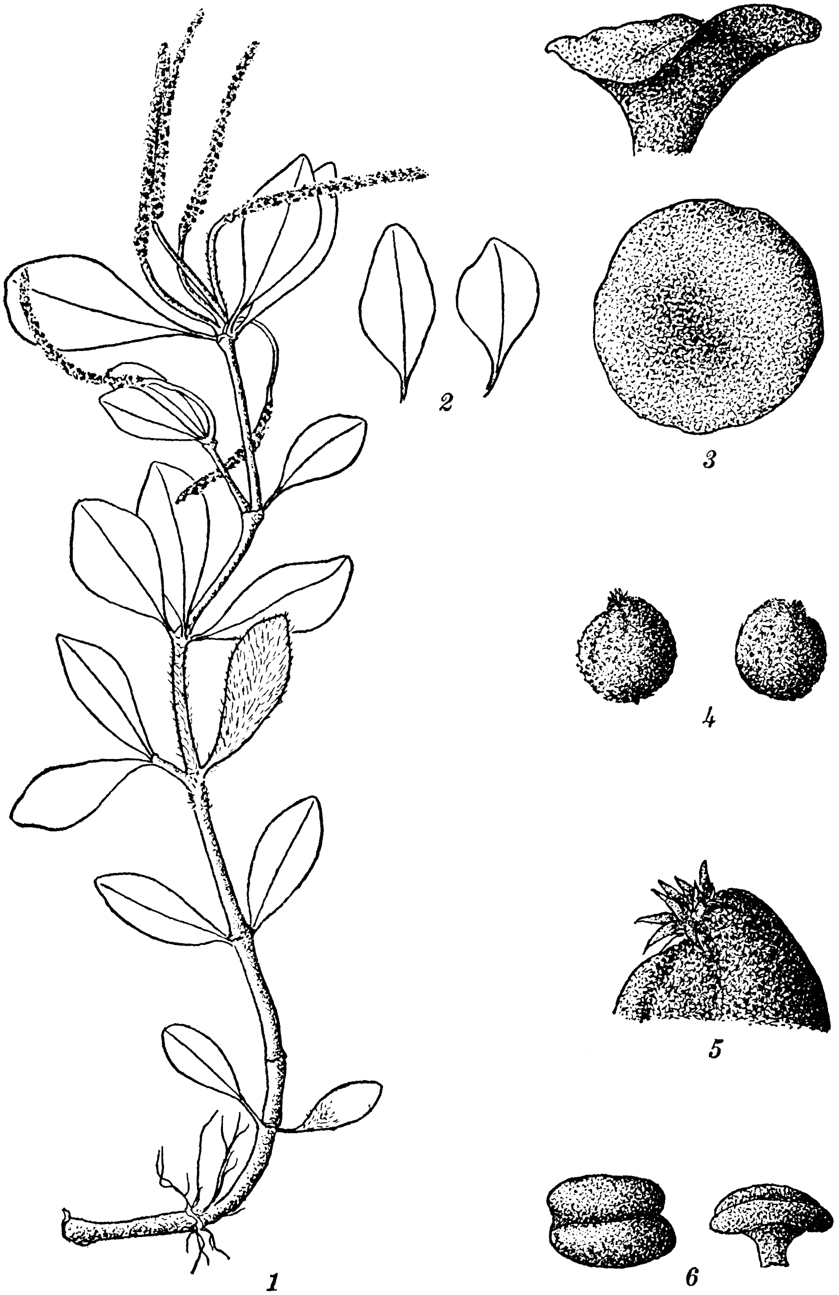

FIG. 120. *Peperomia tomentosa* (Vahl) A. Dietr. var. *carnosa* Miq.; *1*, habit sketch of the plant, × 1; *2*, form of leaves, × 1; *3*, side and top views of bracts, × 80; *4*, fruits, × 20; *5*, detail of stigma, × 80; *6*, stamens, × 80.

MINDANAO, Lanao Province, Camp Keithley, Lake Lanao, *Clemens 517, s. n.* 1906: Bukidnon Province, without definite locality, *Bur. Sci. 15718 Fénix.* Java.

Among the Philippine species, *Peperomia marivelesana* is close to this species. It is characterized by being ochraceo-tomentose throughout, its fleshy subrhomboid-elliptic to subobovate-elliptic leaves, and its penicillate stigmas which are a little below the apex.

18. **PEPEROMIA LATIBRACTEATA** sp. nov. Text fig. 121; Plate 18.

Herba erecta, basi decumbente, carnosa, tomentosa; foliis oppositis vel ternatis, subobovato-ellipticis ad oblanceolatis 2 ad 4 cm longis, 1.2 ad 1.8 cm latis, basi acutis, 3-nerviis, apice obtusis ad rotundatis, membranaceis, utrinque tomentosis, apice marginibusque ciliatis; petiolis tomentosis, 4 ad 7 mm longis; spicis erectis, solitariis vel binis, rarissime ternis, terminalibus et axillaribus, densifloris, 4 ad 7 cm longis; pedunculis tomentosis, 15 ad 22 mm longis; rachis glabris, carnosis, 1.25 ad 2 mm diametro; bracteis pedicellatis, peltatis, peltis orbicularis, 1 ad 1.25 mm latis, membranaceis, glabris; ovario libero, ovoideo ad subobovoideo; stigmatibus penicillatis; baccis liberis, verruculosis, ellipsoideo-ovoideis, circiter 1 mm longis, 0.75 ad 0.8 mm diametro; staminibus pedicellatis, antheris reniformibus.

Stem erect, decumbent at the base, tomentose, fleshy, 17 to 25 cm high, 1.5 to 2.5 mm in diameter, rooting below, very sparingly branched, the branches tomentose. Leaves opposite or ternate, subobovate-elliptic to oblanceolate, 2 to 4 cm long, 1.2 to 1.8

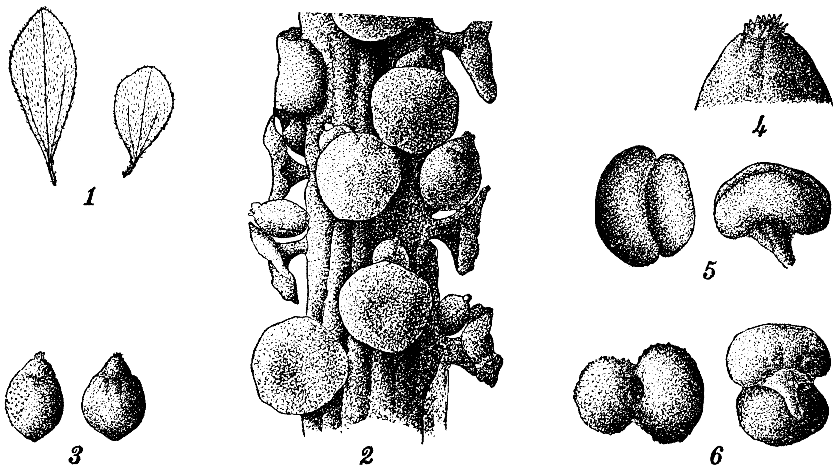

FIG. 121. *Peperomia latibracteata* sp. nov.; *1*, leaves, × 0.5; *2*, detail of a portion of the spike, × 10; *3*, fruits, × 10; *4*, detail of stigma, × 40; *5*, stamens before dehiscence, × 40; *6*, stamens after dehiscence, × 40.

cm wide, base acute, 3-nerved, apex obtuse to rounded, membranaceous, opaque, tomentose on both surfaces, apex and margins conspicuously ciliate; petioles tomentose, 4 to 7 mm long. Spikes erect, solitary or binate, very rarely ternate, terminal and axillary, fleshy, densely flowered, 4 to 7 cm long; the peduncles tomentose, slender, 15 to 22 mm long; rachis glabrous, 1.25 to 2 mm in diameter; bracts pedicellate, peltate, disk membranaceous, glabrous, orbicular, 1 to 1.25 mm wide; ovaries free, ovoid to subobovoid; stigma terminal, penicillate; fruits free, verruculose, brown, ellipsoid-ovoid, about 1 mm long, 0.75 to 0.8 mm in diameter; stamens pedicellate, anthers reniform, filaments as long as the anthers.

LUZON, Nueva Viscaya Province, Campote, *Bur. Sci. 20126 McGregor* (type), Jan. 15, 1913: Ifugao Subprovince, Mount Polis, *Bur. Sci. 19635 McGregor*, Feb. 11, 1913.

A species closely allied to *Peperomia tomentosa* (Vahl) A. Dietr. var. *carnosa* Miq., differing in its larger, membranaceous bracts, its larger free fruits, its larger leaves, and its terminal stigma.

19. **PEPEROMIA RUBRIVENOSA** C. DC. Text fig. 122.

Peperomia macgregorii C. DC., in Philip. Journ. Sci. 5 (1910) Bot. 409, Candollea 1 (1923) 408; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

Peperomia macgregorii C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 412, Candollea 1 (1923) 358; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Peperomia pauaiana C. DC. in Candollea 1 (1923) 402, *nomen nudum*, 2 (1925) 188.

Stem erect or with procumbent base, sparsely pilose, 18.5 to 30.5 cm high, 1.5 to 2 mm in diameter, rooting below, sparingly and dichotomously branched above, the branches pilose. Leaves opposite, sometimes ternate above, very rarely alternate below, obovate to rounded-ovate, 1.4 to 2.5 cm long, 1 to 2 cm wide, base acute, 3-nerved, apex obtuse to rounded, glabrous on both surfaces to sparsely pilose on both surfaces, apex and margins ciliate, epunctulate, reticulations somewhat distinct; petioles subglabrous to pilose, slender, usually 2 to 4 mm long, rarely 6 mm. Spikes erect, solitary to quaternate, axillary and terminal, fleshy, subdensely flowered, 4.5 to 9.5 cm long; the peduncles glabrous, slender, 8 to 23 mm long; rachis glabrous; bracts subsessile, peltate, disk membranaceous, epunctulate, orbicular, about 0.5 mm wide; ovaries immersed, obovoid; stigma a little below the apex, globose, entire, glabrous; fruits subglobose to globose, 0.8 to 1 mm long, 0.75 to 0.8 mm in diameter, verruculose,

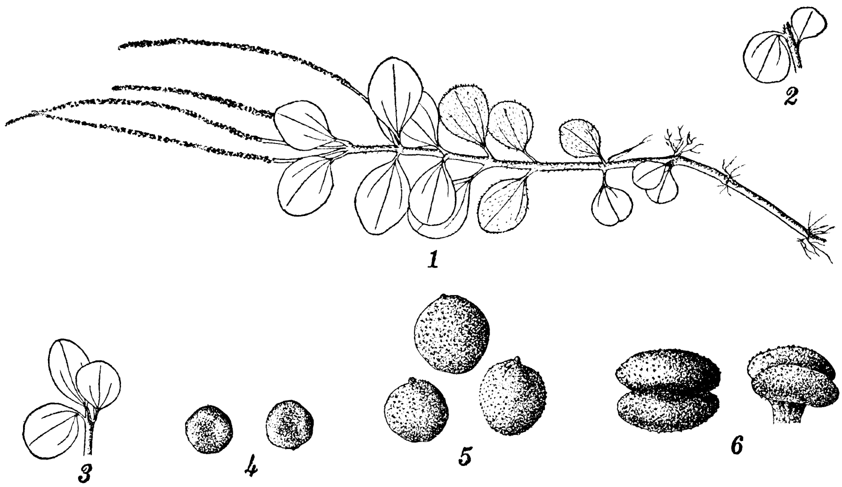

FIG. 122. *Peperomia rubrivenosa* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, leaves alternately disposed, × 0.5; *3*, leaves in whorls, × 0.5; *4*, top view of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

brown; stamens subsessile, anthers ellipsoid, hirtellous, filaments slightly longer than the anthers.

LUZON, Benguet Subprovince, Mount Pauai, *Bur. Sci. 8380* (type collection of *Peperomia macgregorii* C. DC.), *8461 Mcgregor* (type collection of *Peperomia pauaiana* C. DC. (*pauaiana*, sphalm); Baguio, *Williams 1083* (type of *Peperomia rubrivenosa* C. DC. in herb. Manila): Rizal Province, Mount Angilog, *Bur. Sci. 42051 Lopez*. On trees at higher altitudes. Endemic.

This species approaches *Peperomia rivulorum* C. DC., but that is a considerably larger and erect plant, with numerous terminal and solitary spikes. The leaves and bracts, furthermore, are epunctulate and the fruits larger, with the stigma situated a little below the top and the anthers hirtellous without.

20. PEPEROMIA LANAOENSIS C. DC. Text fig. 123.

Peperomia lanaoensis C. DC. in Philip. Journ. Sci. 5 (1910) Bot. 410, Candollea 1 (1923) 327; MERR., Enum. Philip. Fl. Pl. 2 (1923) 19.

Stem procumbent, slender, rooting at the nodes, glabrous, sparingly branched, the branches glabrous. Leaves alternate, rounded-ovate, 10 to 18 mm long, 10 to 19 mm wide, base truncate to subcordate, 5-nerved, apex obtuse to rounded, subpellucid to pellucid, glabrous on both surfaces, reticulations prominent; petioles glabrous, slender, 6 to 16 mm long. Spike solitary, leaf-opposed, and terminal, fleshy, densely flowered, 20 to 35 mm long, 1.25 to 2 mm in diameter; the peduncles glabrous, slender,

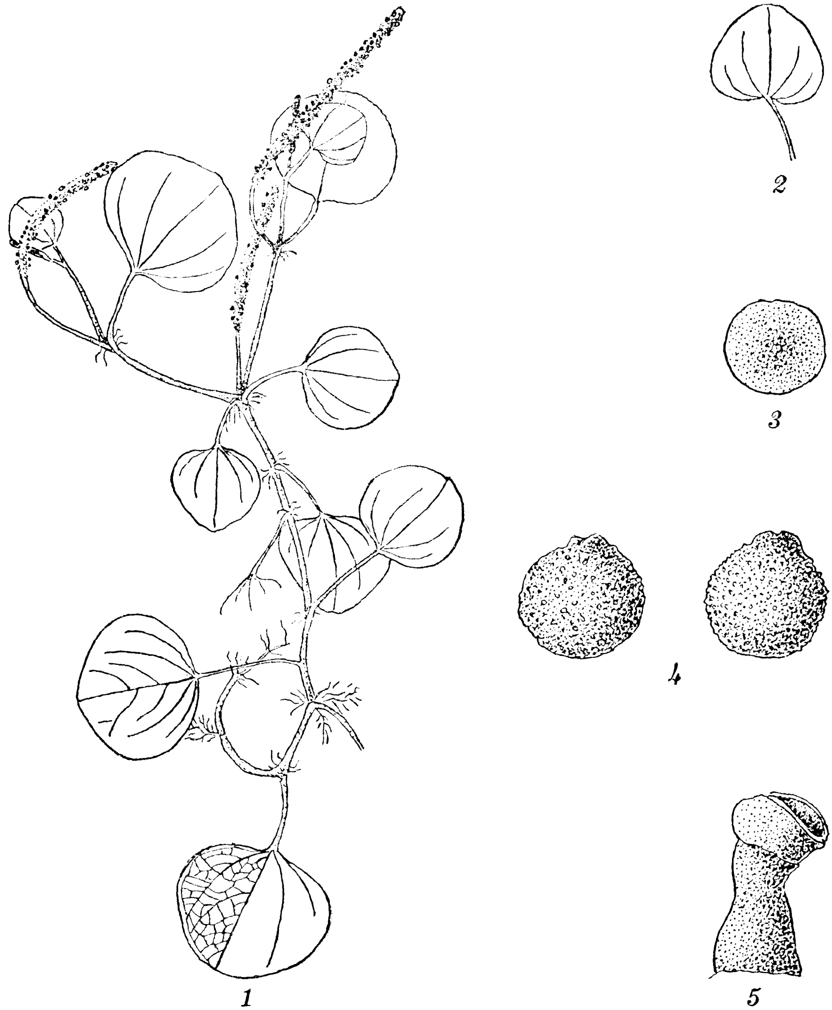

FIG. 123. *Peperomia lanaoensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, a leaf, × 1; *3*, top view of bract, × 20; *4*, fruits, × 20; *5*, stamen, × 80.

4 to 8 mm long; rachis glabrous; bracts sessile, peltate, disk pellucid, orbicular, 0.4 to 0.6 mm wide; ovaries immersed; stigma terminal, bilobed; fruits partly immersed, globose, 0.6 to 0.75 mm long, 0.5 to 0.75 mm in diameter, glabrous, verruculose; stamens pedicellate, 0.3 to 0.4 mm long, anthers oblong, filaments longer than the anthers.

LUZON, Rizal Province, Mount Irid, *Bur. Sci. 48500 Ramos and Edaño*. SAMAR, Loquilocon, *Bur. Sci. 43791 McGregor*.

MINDANAO, Bukidnon Province, Tangkulan, *Bur. Sci. 26045 Fénix:* Lanao Province, Maria Cristina Falls, *Clemens 625* (type collection) : Zamboanga Province, without definite locality, *Merrill 8152.* On rocks and ledges in ravines and near streams at low and medium altitudes. Endemic.

A species close to *Peperomia exigua* (Blume) Miq., differing in its fleshy spikes which are leaf-opposed, its larger globose fruits, its larger leaves and longer petioles.

21. PEPEROMIA RIVULORUM C. DC. Text fig. 124.

Peperomia rivulorum C. DC. in Leafl. Philip. Bot. 3 (1910) 762, Philip. Journ. Sci. 5 (1910) Bot. 412, Candollea 1 (1923) 330; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

Stem prostrate, hirtellous, somewhat slender, rooting at the nodes, branching below, the branches hirtellous, slender. Leaves alternate, oblong-elliptic to rounded-elliptic, 10 to 20 mm long, 8 to 15 mm wide, base acute, 3- to 5-nerved, apex obtuse to rounded, membranaceous, opaque, puberulent and black-punctulate on both surfaces, margins and apex ciliate, reticulations somewhat distinct; petioles hirtellous, slender, 3 to 8 mm long. Spike erect, solitary, leaf-opposed, and terminal, subfiliform, somewhat densely flowered, 25 to 45 mm long; the peduncles hirtellous, 9 to 15 mm long; rachis glabrous; bracts subsessile, peltate, disk membranaceous, orbicular, 0.5 to 0.6 mm wide; ovaries immersed, oblong-ovoid; stigma terminal, entire, globose, glabrous; fruits oblong-ovoid, 0.6 to 0.75 mm long, 0.5 to 0.6 mm in diameter, verrucose, brown; stamens subsessile, anthers ellipsoid.

MINDANAO, Davao Province, Todaya, Mount Apo, *Elmer 11147* (type collection) ; Catalonan, *Copeland 933.* On mossy bowlders. Endemic.

Local name: Lambu-lambú (Bag.).

The alliance of this species is apparently with *Peperomia lanaoensis* C. DC. from which it is distinguished by its pubescent stems, branches, petioles, peduncles, and opaque leaves with acute bases, and by its long, subfiliform spikes.

EXCLUDED SPECIES

PEPEROMIA ARGYREIA Morren.

Peperomia argyreia MORREN in Belg. Hort. 17 (1867) 2, *t. 2;* MERR., Fl. Manila (1912) 170, Enum. Philip. Fl. Pl. 2 (1923) 21; C. DC., Candollea 1 (1923) 375.

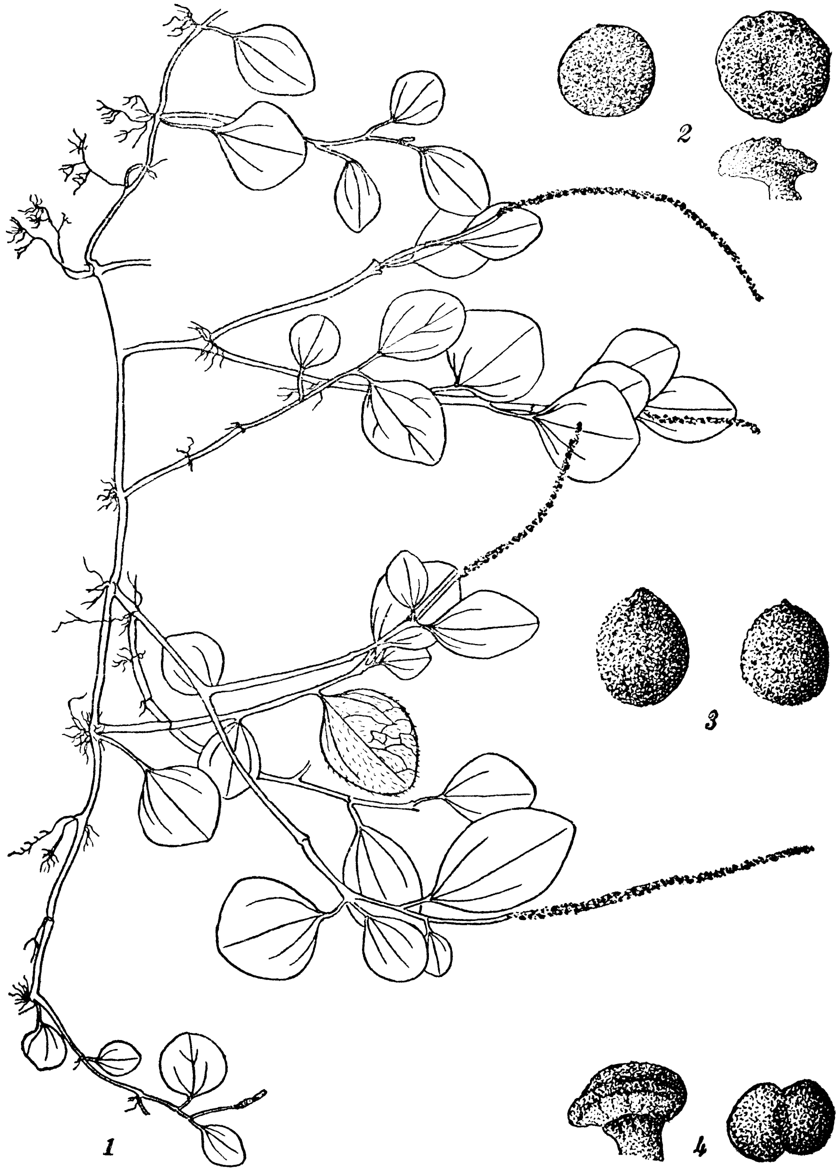

FIG. 124. *Peperomia rivulorum* C. DC.; *1*, habit sketch of the plant, × 1; *2*, top and side views of bracts, × 20; *3*, fruits, × 20; *4*, stamen, × 80.

An exotic species of American origin, now cultivated in Manila and other provinces for its variegated leaves, but giving no indications of becoming naturalized.

PEPEROMIA BILINEATA (Blume) Miq.

Peperomia bilineata (Blume) MIQ., Syst. Pip. (1843) 106, Fl. Ind. Bat. 1[2] (1858–59) 433; C. DC., Prodr. 16[1] (1869) 419, Candollea 1 (1923) 336; USTERI, Beitr. Ken. Philip. Veg. (1905) 125; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

Piper bilineatum BLUME in Verh. Bat. Genoots. 11 (1826) 231, *f. 35*.

Usteri's Guimaras specimen was probably wrongly identified. Miquel in Nov. Act. Acad. Nat. Cur. 19 (1843) Suppl. 1: 485, also cites *Manila* as a locality. This species was described from Javan material.

PEPEROMIA MARIANNENSIS C. DC.

Peperomia mariannensis C. DC., Prodr. 16[1] (1869) 442, Candollea 1 (1923) 317; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

A Guam species erroneously credited by F.-Villar to the Philippines.

PEPEROMIA MEMBRANACEA Hook. and Arn.

Peperomia membranacea HOOK. and ARN. in Bot. Beech. Voy. (1832) 96; C. DC., Prodr. 16[1] (1869) 459, Candollea 1 (1923) 304; F.-VILL., Novis. App. (1880) 176; MERR., Enum. Philip. Fl. Pl. 2 (1923) 21.

A species erroneously credited to the Philippines by F.-Villar. It is reported from Hawaii and Guam.

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ILLUSTRATIONS

PLATE 1

Piper trichophlebium sp. nov.; type.

PLATE 2

Piper medinillifolium sp. nov.; type.

PLATE 3

Piper simile sp. nov.; type. Female plant.

PLATE 4

Piper simile sp. nov. Male plant.

PLATE 5

Piper melanocaulon sp. nov.; type.

PLATE 6

Piper aristolochiphyllum sp. nov.; type.

PLATE 7

Piper fuscinervum sp. nov.; type.

PLATE 8

Piper asterostigmum sp. nov.; type.

PLATE 9

Piper sibulanum C. DC.; type.

PLATE 10

Piper parong sp. nov.; type.

PLATE 11

Piper ensifolium sp. nov.; type.

PLATE 12

Piper cordatilimbum sp. nov.; type.

PLATE 13

Piper longipedicellatum sp. nov.; type.

PLATE 14

Piper paucinerve C. DC.; type.

PLATE 15

Piper spathelliferum sp. nov.; type.

PLATE 16

Piper nigrum Linn. var. *trioicum* (Roxb.) C. DC. (Type of *Piper glabrispicum* C. DC.)

PLATE 17. TYPES OF PISTILLATE SPIKES.

FIG. 1. *Piper interruptum* Opiz.
2. *Piper caninum* Blume.
3. *Piper baccatum* Blume.
4. *Piper sarcopodum* C. DC.
5. *Piper arborescence* Roxb.
6. *Piper philippinum* Miq.
7. *Piper ovatibaccum* C. DC.
8. *Piper betle* Linn.
9. *Piper abbreviatum* Opiz.
10. *Piper baguionum* C. DC.
11. *Piper umbellatum* Linn. var. *subpeltatum* (Willd.) C. DC.

PLATE 18

Peperomia latibracteata sp. nov.; type.

PLATE 19

Piper firmolimbum C. DC.

PLATE 20

Piper abbreviatum Opiz; type.

PLATE 21

Piper interruptum Opiz; type.

PLATE 22

Piper celtidiforme Opiz; type.

PLATE 23

Piper denudatum Opiz; type.

PLATE 24

Piper denudatum Opiz. The spike contained in the pocket, enlarged.

TEXT FIGURES

FIG. 1. *Piper umbellatum* Linn. var. *subpeltatum* (Willd.) C. DC.; *1*, leaf, × 0.25; *2*, top view of bract, × 5; *3*, side view of bract, × 5; *4*, seeds, × 12.5; *5*, stamens, × 40.

2. *Piper arborescens* Roxb.; *1–4*, leaves, × 0.5; *7*, leaf base, upper surface, × 0.5; *8*, leaf base, lower surface, × 0.5; *9*, mature pistillate spike, transverse section, × 7.5; *10*, fruits and seeds, ×7.5; *12*, portion of mature staminate spike, × 5; *13*, side and top views of staminate bracts, × 7.5; *14*, stamen, × 15; var. *angustilimbum* var. nov.; *5–6*, leaves, × 0.5; *11*, fruits, × 7.5.

3. *Piper trichophlebium* sp. nov.; *1*, leaf, × 0.5 *2*, fruits, × 10; *3*, portion of the transverse section of mature pistillate spike, × 10; *4*, mature pistillate spike, × 0.5.

4. *Piper pilipes* C. DC.; *1–2*, leaves, × 0.5; *3*, side and top views of bracts, × 10; *4*, seed, × 10; *5*, fruits, × 10; *6*, mature pistillate spike, × 0.5.

FIG. 5. *Piper brevicuspe* (Miq.) Merr.; *1*, leaf, × 0.5; *2*, apex of a leaf, × 0.5; *3*, mature pistillate spike and stipules, × 0.5; *4*, longitudinal section of a fruit, a bract and three stigmas, × 10; *5*, same with two stigmas, × 10; *6*, staminate spike, × 0.5; *7*, detail of a portion of 6 showing arrangement of bracts, about × 2; *8*, lower view of disk of ♀ bract, × 10; *9*, side view of disk of ♀ bract, × 10; *10*, side view of ♂ bract, × 10; *11*, lower view of disk of ♂ bract, × 10; *12*, hairs on bracts, much enlarged; *13*, stamen, × 10.

6. *Piper medinillifolium* sp. nov.; *1*, leaf, × 0.5; *2*, top and side views of pistillate bracts, × 10; *3*, fruits and pistillate bract, × 7.5.

7. *Piper toppingii* C. DC.; *1–5*, leaves, × 0.5; *6*, transverse section of mature pistillate spike, × 7.5; *7*, side and top views of pistillate bracts, × 10; *8*, fruits, × 7.5; *9*, side view of staminate bracts, × 10; *10*, stamens, × 10.

8. *Piper urdanetanum* C. DC.; *1–3*, leaves, × 0.5; *3a*, mature pistillate spike, × 0.5; *4*, transverse section of mature pistillate spike, × 7.5; *5*, side view of pistillate bracts, × 10; *6*, fruits, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, *a*, before dehiscence, *b*, after dehiscence, × 10.

9. *Piper simile* sp. nov.; *1*, habit, male plant, × 0.5; *2*, portion of the transverse section of a mature pistillate spike, × 7.5; *3*, fruits, × 7.5; *4*, side and top views of pistillate bracts, × 10; *5*, habit, female plant, 0.5; *6*, leaf, × 0.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, × 10.

10. *Piper lessertianum* (Miq.) C. DC.; *1–2*, leaves, × 0.5; *3*, portion of pistillate spike, × 0.5; *4*, fruits, × 7.5; *5*, longitudinal section of fruits and ♀ bracts, × 7.5; *6*, portion of staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamens, × 10.

11. *Piper lessertianum* (Miq.) C. DC. var. *oblongibaccum* (C. DC.) comb. nov.; leaves, × 0.5.

12. *Piper subprostratum* C. DC.; typical leaves, × 0.5.

13. *Piper subprostratum* C. DC.; *1*, top and side views of pistillate bracts, × 7.5; *2*, fruit, × 7.5; *3*, longitudinal section of a fruit, × 7.5; *4*, top and side views of staminate bracts, × 7.5; *5*, stamens, × 7.5.

14. *Piper decumanum* Linn.; *1*, leaf, × 0.5; *2*, tip of a leaf, × 0.5; *3*, portion of the pistillate spike, × 0.5; *4*, pistillate bract, × 7.5; *5*, young fruit and bract, × 7.5; *6*, fruits and seed, × 7.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamen, × 7.5; *9*, portion of staminate spike, × 0.5.

15. *Piper lageniovarium* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bracts, × 7.5; *3*, ovaries and stigmas, × 7.5.

16. *Piper majusculum* Blume; *1*, leaf with one side cut, × 0.5; *2*, lobe of the base of a leaf, × 0.5; *3*, tip of a leaf, × 0.5; *4*, stipule, × 0.5; *5*, portion of the pistillate spike, × 0.5; *6*, top

view of portion of the pistillate spike, slightly enlarged; *7*, side and top views of pistillate bracts, × 7.5; *8*, staminate spike, × 0.5; *9*, portion of the staminate spike, × 1.5; *10*, seeds, × 5; *11*, top and side views of staminate bracts, × 7.5; *12*, stamens, × 7.5.

FIG. 17. *Piper cupodum* C. DC.; *1*, fruiting branch, × 0.5; *2*, leaf, × 0.5; *3*, fruit with a bract attached, × 10; *4*, top and apical side views of pistillate bracts, × 10; *5*, top and side views of staminate bracts, × 10; *6*, stamens, × 10.

18. *Piper melanocaulon* sp. nov.; *1*, a fruiting branch, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, portion of the transverse section of a mature pistillate spike, × 7.5; *4*, side view of pistillate bracts, × 7.5.

19. *Piper agusanense* C. DC.; *1*, leaf, × 0.5; *2*, leaf base, × 0.5; *3*, lower leaf, × 0.5; *4*, mature pistillate spike, × 0.5; *5*, top view of a fruit and a bract, × 7.5; *6*, transverse section of a mature pistillate spike, × 7.5; *7*, mature staminate spike, × 0.5; *8*, top view of staminate bracts, × 7.5; *9*, side view of a stamen, × 40; *10*, median section of two stamens, × 40.

20. *Piper merrillii* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, submature fruit and bracts, × 7.5; *5*, mature fruit, × 7.5; *6*, staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamens, × 7.5.

21. *Piper aristolochiphyllum* sp. nov.; *1*, leaf, × 0.5; *2*, staminate spike, × 0.5; *3*, side and top views of staminate bracts, × 7.5; *4*, stamens, × 7.5.

22. *Piper aurilimbum* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, top and side views of pistillate bracts, × 7.5; *5*, fruit and apices of fruits, × 7.5; *6*, staminate spike, × 0.5; *7*, top and side views of staminate bracts, × 7.5; *8*, stamens, × 7.5.

23. *Piper myrmecophilum* C. DC.; *1*, leaf, × 0.5; *2*, base of a leaf and mature pistillate spike, × 0.5; *3*, fruit with long style and bracts, × 7.5; *4*, detail of bifid stigmas, × 10; *5*, seeds, × 7.5; *6*, detail of a projection from the pistillate bract, × 10; *7*, base of a leaf and mature staminate spike, × 0.5; *8*, top and side views of bracts and stamen, × 7.5.

24. *Piper abbreviatum* Opiz; *1*, flowering branch of a male plant, × 0.5; *2–3*, leaves, × 0.5; *4*, flowering branch of a female plant, × 0.5; *5*, lower leaf, × 0.5, *6–7*, leaves, × 0.5.

25. *Piper abbreviatum* Opiz; *1*, mature pistillate spike, natural size; *2*, top and side views of pistillate bracts, × 10; *3*, portion of the transverse section of mature pistillate spike, × 7.5; *4*, typical seeds and fruit, × 7.5; *5*, larger form of seeds, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, ×10.

26. *Piper breviamentum* C. DC.; leaves, × 0.5.

27. *Piper breviamentum* C. DC.; *1*, portion of the transverse section of a mature pistillate spike, × 7.5; *2*, seeds, × 7.5; *3*, side and top views of staminate bracts, × 10; *4*, stamens, × 10.

FIG. 28. *Piper parcirameum* C. DC.; *1–3*, leaves, × 0.5; *4*, top and side views of pistillate bracts, × 10; *5*, fruits, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

29. *Piper costulatum* C. DC.; *1*, leaf with young pistillate spike, × 0.5; *2*, leaf with mature staminate spike, × 0.5; *3*, base of a leaf and mature pistillate spike, × 0.5; *4*, leaf base, × 0.5; *5*, leaves and young staminate spike, × 0.5; *6*, flowering male branch, × 0.5; *7*, top view of stigmas, × 10; *8*, top and side views of pistillate bracts, × 7.5; *9*, fruits, × 7.5; *10*, portion of the transverse section of a mature pistillate spike, × 7.5; *11*, top and side views of staminate bracts, × 10; *12*, stamens, × 10.

30. *Piper cacuminum* C. DC.; *1*, leaf and mature pistillate spike, × 0.5; *2*, side view of pistillate bracts, × 7.5; *3*, fruit, × 7.5; *4*, top view of a fruit, × 7.5; *5*, seeds, × 7.5.

31. *Piper halconense* C. DC.; *1–5*, leaves, × 0.5; *6*, young fruit with bract attached, × 10; *7*, side view of a pistillate bract, × 10; *8*, mature fruit with bract attached, × 10; *9*, side and top views of staminate bracts, × 10; *10*, stamens, × 10.

32. *Piper atrospicum* (. DC.; *1*, leaf, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, fruits, × 7.5; *4*, side and top views of pistillate bracts, × 7.5; *5*, portion of the transverse section of mature pistillate spike, × 7.5.

33. *Piper longivaginans* C. DC.; *1–2*, leaves, × 0.5; *3*, detail of petiole, enlarged; *4*, branch, × 0.5; *5*, leaf and mature staminate spike, × 0.5; *6*, mature pistillate spike, × 0.5; *7*, apex of the pistillate spike, × 2.25; *8*, fruits, × 5; *9*, seeds, × 5; *10*, top view of pistillate bracts, × 10; *11*, top view of staminate bracts, × 10; *12*, side view of staminate bract and stamens, × 10.

34. *Piper delicatum* C. DC.; *1*, branch with mature pistillate spike, × 0.5; *2*, flowering branch of a male plant, × 0.5; *3* flowering branch of a male plant, × 0.5; *4*, flowering branch of a female plant, × 0.5; *5*, apex of a pistillate spike, × 2.25; *6*, top and side views of pistillate bracts, × 10; *7*, portion of the transverse section of a mature pistillate spike, × 7.5; *8*, fruits with bracts attached, × 7.5; *9*, seeds, × 7.5; *10*, top and side views of staminate bracts, × 10; *11*, stamens, × 10.

35. *Piper curtifolium* C. DC.; *1–4*, leaves, × 0.5; *5*, portion of pistillate spike, × 7.5; *6*, fruits, × 7.5; *7*, side view of pistillate bracts, × 7.5; *8*, side and top views of staminate bracts, × 10; *9*, stamens, × 10.

36. *Piper varibracteum* C. DC.; *1–2*, leaves, × 0.5; *3*, leaf and mature pistillate spike, × 0.5; *4*, top view of pistillate bracts, × 7.5; *5*, top view of a fruit, × 7.5; *6*, side view of a fruit, × 7.5; *7*, fruit embedded in the rachis, × 7.5; *8*, portion of the staminate spike, × 10; *9*, stamens, × 10.

37. *Piper mindorense* C. DC.; *1*, leaf, × 0.5; *2*, top and side views of pistillate bracts, × 7.5; *3*, fruit, × 7.5; *4*, seeds, × 8.

FIG. 38. *Piper ovatibaccum* C. DC.; *1–2*, leaves, × 0.5; *3*, branchlet with young staminate spike, × 0.5; *4*, branchlet with young pistillate spike, × 0.5; *5*, portion of the transverse section of a mature pistillate spike, × 7.5; *6*, fruit with bract attached and top view of pistillate bracts, × 7.5; *7*, fruits, × 7.5; *8*, seeds, × 7.5; *9*, side and top views of staminate bracts, × 10; *10*, stamens, × 10.

39. *Piper ramosii* C. DC.; *1–3*, leaves, × 0.5; *4* mature pistillate spike, × 0.5; *5*, top and side views of pistillate bracts, × 7.5; *6*, fruits, × 7.5; *7*, seeds, × 7.5; *8*, staminate spike, × 0.5; *9*, side view of staminate bract, × 40; *10*, top and side views of stamens, × 40.

40. *Piper fuscinervum* sp. nov.; *1*, leaf, × 0.5; *2*, mature pistillate spike, natural size; *3*, top and side views of staminate bracts, × 10; *4*, fruit, × 10; *5*, top and side views of pistillate bracts, × 10; *6*, stamens, × 40.

41. Leaves of: *3–5*, *7*, *Piper betle* Linn.; *1*, var. *densum* (Blume) C. DC.; *2*, var. *macgregorii* (C. DC.) comb. nov.; *6*, var. *fenixii* (C. DC.) comb. nov. All × 0.5.

42. *Piper betle* Linn.; *1*, mature pistillate spike, × 0.5; *2*, top view of pistillate bracts, × 10; *3*, stigmas, × 10; *4*, top view of pistillate bracts (var. *densum*), × 10; *5*, trnasverse section of a mature pistillate spike, × 7.5; *6*, seeds, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, × 10.

43. *Piper langlassei* C. DC.; *1*, fruiting branch, × 0.5; *2*, longitudinal section of a portion of the pistillate spike, × 7; *3*, bracts, × 7; *4*, stigmas, × 7.

44. *Piper asterostigmum* sp. nov.; *1*, mature pistillate spike and base of a leaf, × 0.5; *2*, portion of the mature pistillate spike, enlarged; *3*, top view of bracts, × 7.5; *4*, stigmas, × 7.5; *5*, seeds, × 7.5.

45. *Piper firmolimbum* C. DC.; *1*, *3–4*, leaves, × 0.5; *2*, fruiting branch with mature pistillate spike, × 0.5; *5*, var. *parvilimbum* var. nov., leaf, × 0.5.

46. *Piper firmolimbum* C. DC.; *6*, transverse section of a mature pistillate spike, enlarged; *7*, top view of pistillate bracts, × 10; *8*, young fruits showing stigmas, × 10; *9*, seeds, × 7.5; *10*, top and side views of staminate bracts, × 10; *11*, stamens, × 10.

47. *Piper longistigmum* C. DC.; *1–2*, leaves, × 0.5; *3*, leaf and a mature pistillate spike, × 0.5; *4*, portion of the top view of a mature pistillate spike, × 7.5; *5*, side view of pistillate bracts, × 10; *6*, side view of a pistillate bract and a young fruit, × 10; *7*, top view of pistillate bracts, × 10; *8*, seeds, × 7.5.

48. *Piper baguionum* C. DC.; *1*, fruiting branch, × 0.5; *2–3*, leaves, × 0.5; *4*, young pistillate spike, × 1.8; *5*, mature pistillate spike, × 0.5; *6*, top and side views of pistillate bracts, × 10; *7*, fruit, × 7.5; *8*, seeds, × 2.5; *9*, portion of staminate spike, × 7.5; *10*, side and top views of staminate bracts, × 10; *11*, stamens, × 10.

FIG. 49. *Piper angustipeltatum* Merr.; *1*, leaf, × 0.5; *2*, pistillate spike, × 0.5; *3*, pistil with long style and bilobed stigma, × 10; *4*, top view of bracts, × 10.

50. *Piper fragile* Benth.; *1–4*, leaves, × 0.5; *5*, mature pistillate spike, × 0.5; *6*, top view of fruits, × 2.5; *7*, side and top views of pistillate bracts, × 10; *8*, portion of the transverse section of a pistillate spike, × 7.5; *9*, portion of a staminate spike, × 10; *10*, top view of a staminate bract, × 10; *11*, transverse section of a portion of staminate spike, × 10; *12*, stamens, × 10.

51. *Piper sarmentosum* Roxb.; *1*, fruiting branch, × 0.3; *2–4*, upper leaves, × 0.3; *5*, lower leaf, × 0.3; *6*, side view of pistillate bracts, × 5; *7*, top view of portion of mature pistillate spike, × 5; *8*, transverse section of mature pistillate spike, × 5; *9*, side view of two fruits, × 5; *10*, side and top views of staminate bracts, × 6.5; *11*, stamens before dehiscence, × 6.5; *12*, stamens after dehiscence, × 6.5.

52. *Piper sibulanum* C. DC.; *1*, leaf, × 0.5; *2*, leaf and mature pistillate spike, × 0.5; *3*, leaf and staminate spike, × 0.5; *4*, top view of a portion of a mature pistillate spike, × 7.5; *5*, seeds, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

53. *Piper parong* sp. nov.; *1*, leaf, × 0.5; *2*, fruits, × 7.5; *3*, seeds, × 7.5; *4*, top and side views of bracts, × 10; *5*, stamens, × 10.

54. *Piper retrofractum* Vahl; leaves, × 0.5.

55. *Piper retrofractum* Vahl; *1–2*, leaves, × 0.5; *3*, top view of pistillate bracts, × 10; *4*, longitudinal section of a fruit, × 7.5; *5*, mature pistillate spike, × 0.5; *6*, transverse section of a mature pistillate spike, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, × 10.

56. *Piper philippinum* Miq.; *1–2*, *4–5*, leaves, × 0.5; *3*, leaf and part of the pistillate spike, × 0.5.

57. *Piper philippinum* Miq.; leaves, × 0.5.

58. *Piper philippinum* Miq.; *1*, portion of mature pistillate spike, × 1.5; *2*, transverse section of a mature pistillate spike, × 7.5; *3*, top and side views of pistillate bracts, × 10; *4*, fruits, × 7.5; *5*, seeds, × 7.5; *6*, transverse section of a staminate spike, × 10; *7*, top and side views of staminate bracts × 10; *8*, sterile ovaries, × 10; *9*, stamens before and after dehiscence, × 10.

59. *Piper albidirameum* C. DC.; *1–2*, leaves, × 0.5; *3*, mature pistillate spike, × 0.5; *4*, staminate spike, × 0.5; *5*, portion of staminate spike, × 2.

60. *Piper maagnasanum* C. DC.; *1–3*, leaves, × 0.3; *4*, longitudinal section of a fruit, × 5; *5*, same, with a bract attached, × 5.

61. *Piper ensifolium* sp. nov.; *1*, leaf, × 0.5; *2*, portion of a young pistillate spike, × 3; *3*, top view of a pistillate bract, × 7.5; *4*, portion of a pistillate spike, × 2; *5*, side view of pistillate bracts and an ovary, × 7.5.

FIG. 62. Leaves of: *1–2*, *Piper caninum* Blume; *3*, var. *glabribracteum* C. DC.; *4–6*, var. *lanaoense* C. DC.; *7*, var. *oblongifolium* var. nov.; *8–9*, var. *basilanum* C. D.C. All × 0.3.

63. *Piper caninum* Blume; *7*, pistillate spike; *8*, leaves. Var. *hallieri* (C. DC.) comb. nov.; *1–2*, leaves. Var. *latibracteum* C. DC.; *3–6*, leaves. All × 0.3.

64. Fruits of: *1–3*, *Piper caninum* Blume; *4*, var. *glabribracteum* C. DC.; *5*, var. *lanaoense* C. DC.; *6*, var. *oblongifolium* var. nov.; *7*, var. *hallieri* (C. DC.) comb. nov.; *8*, var. *basilanum* (C. DC.) comb. nov.; *9*, var. *latibracteum* C. DC. All × 5.

65. *Piper caninum* Blume; *1*, portion of the pistillate spike showing bracts and rachis, × 7.5; *8*, apex of staminate spike, × 7.5; *9*, side and lower views of staminate bracts, × 7.5; *10*, transverse section of staminate spike, × 7.5. Var. *glabribracteum* C. DC.; *2*, portion of pistillate spike showing bracts, rachis and fruit pedicels, × 7.5. Var. *lanaoense* C. DC.; *3*, top and side views of pistillate bracts, × 10. Var. *oblongifolium* var. nov.; *4*, top and side views of pistillate bracts, × 10. Var. *hallieri* (C. DC.) comb. nov.; *5*, top and side views of pistillate bracts, × 10. Var. *basilanum* (C. DC.) comb. nov.; *6*, top and side views of pistillate bracts, × 10. Var. *latibracteum* C. DC.; *7*, top and side views of pistillate bracts, × 10.

66. *Piper viminale* Opiz; *1*, branch of the male plant; *2*, upper leaf of male plant; *3*, lower leaf; *4*, leaf; *5*, branch of the female plant; *6*, lower leaf; *7–8*, leaves. All × 0.5.

67. *Piper viminale* Opiz; *1*, pistillate spike, × 0.5; *2*, portion of rachis of pistillate spike, × 7.5; *3–4*, fruits, × 7.5; *5*, top and side views of staminate bracts, × 10; *6*, two stamens, × 10; *7*, anthers, after and before dehiscence, very much enlarged. *Piper apoanum* C. DC.; *8*, fruiting branch, × 0.5; *9*, lower leaf, × 0.5; *10*, portion of pistillate spike, × 7.5.

68. *Piper densibaccum* C. DC.; *1*, leaf, × 0.5; *2*, portion of the pistillate spike, × 7.5; *3*, fruit, × 7.5.

69. *Piper dagatpanum* C. DC.; *1*, leaf, × 0.5; *2*, lower leaf, × 0.5; *3*, leaf and pistillate spike, × 0.5; *4*, portion of the pistillate spike, × 7.5.

70. *Piper dipterocarpinum* C. DC.; *1*, leaf, × 0.5; *2*, fruiting branch of pistillate plant, × 0.5; *3*, leaf and staminate spike, × 0.5; *4*, portion of pistillate spike, × 7.5; *5*, portion of staminate spike, × 7.5; *6*, side and top views of staminate bracts, × 10; *7*, stamen, before dehiscence, × 10; *8*, stamens, after dehiscence, × 10.

71. *Piper sablanum* (C. DC.) comb. nov.; *1–2*, leaves, × 0.3; *3–4*, fruits, × 5; *5*, top and side views of pistillate bracts, × 5.

72. *Piper tenuipedunculum* C. DC.; *1*, leaf, × 0.5; *2*, apical portion of branch, showing leaf and peduncle, × 0.5; *3*, top view of pistillate bracts, × 10; *4–5*, fruits, × 7.5.

73. *Piper malalaganum* C. DC.; *1*, branch, × 0.3; *2–3*, leaves, × 0.3; *4*, pistillate spike, × 0.3; *5*, top view of pistillate bracts, × 5; *6*, portion of pistillate spike, × 5; *7*, fruit, × 5.

FIG. 74. *Piper haenkeanum* Opiz; *1–2*, leaves, × 0.3; *3*, branch of a male plant, × 0.3; *4*, leaf, × 0.3; *5–6*, lower leaves, × 0.3; *7–10*, fruits, × 5; *11*, top, lower, and side views of pistillate bracts, × 6.5; *12*, portion of staminate spike, × 6.5; *13*, top view of staminate bracts, × 6.5.

75. *Piper cordatilimbum* sp. nov.; *1–4*, leaves, × 0.3; *5*, ovary, × 6.5; *6*, side view of pistillate bract, × 6.5; *7*, top view of pistillate bracts, × 6.5; *8–10*, fruits, × 5.

76. *Piper cabadbaranum* C. DC.; *1–3*, leaves, × 0.5; *4*, pistillate spike, × 0.5; *5*, side and top views of pistillate bracts, × 10; *6*, portion of pistillate spike, × 7.5.

77. *Piper longipedicellatum* sp. nov.; *1*, fruiting branch with lower portion of pistillate spike, × 0.5; *2*, lower leaf, × 0.5; *3*, top and side views of pistillate bracts, × 10; *4*, portion of pistillate spike, × 7.5.

78. *Piper arborisedens* C. DC.; *1*, leaves, × 0.5; *2*, pistillate spike, × 0.5; *3*, portion of pistillate spike, × 7.5; *4*, fruit, × 7.5.

79. *Piper acutibaccum* C. DC.; *1*, typical leaf and lower portion of pistillate spike, × 0.5; *2*, portion of pistillate spike, × 7.5; *3*, top and side views of pistillate bracts, × 10.

80. *Piper paucinerve* C. DC.; *1*, typical leaf, × 0.5; *2*, portion of the pistillate spike, × 0.5; *3*, top view of pistillate bracts, × 7.5; *4*, fruits, × 7.5.

81. *Piper brevistigmum* C. DC.; *1–3*, leaves, × 0.5; *4*, top view of pistillate bracts, × 10; *5*, fruits, × 7.5.

82. *Piper sorsogonum* C. DC.; *1–2*, leaves, × 0.5; *3*, pistillate spike, × 0.5; *4*, hairs on the bracts, much enlarged; *5*, fruit and portion of the rachis, × 7.5; *6*, top and side views of pistillate bracts, × 7.5.

83. *Piper elmeri* Merr.; typical leaf of the female plant with portion of the pistillate spike, × 0.5.

84. *Piper elmeri* Merr.; *1*, portion of pistillate spike, × 7.5; *2*, top and side views of pistillate bracts, × 7.5; *3*, portion of staminate spike, × 7.5; *4*, top view of staminate bracts, × 7.5; *5*, stamens, × 7.5.

85. Leaves of: *1–3*, *Piper interruptum* Opiz; *4–6*, var. *loheri* (C. DC.) comb. nov.; *7–11*, var. *cumingianum* (Miq.) comb. nov.; *12*, var. *laevirameum* C. DC.; *13–14*, var. *multiplinerve* C. DC. All × 0.3.

86. *Piper interruptum* Opiz; *1*, pistillate spike, × 0.5; *2*, bracts and ovaries on young pistillate spike, × 1.5; *3*, top view of pistillate bracts, × 7.5; *4–5*, fruits, × 2.5; *6–9*, fruits, × 7.5; *10*, longitudinal section of a fruit, × 10; *11*, bracts on the staminate spike, × 3; *12*, portion of staminate spike, enlarged; *13*, top view of staminate bracts, × 7.5; *14*, stamens, × 7.5.

87. *Piper davaoense* C. DC.; *1–4*, leaves, × 0.5; *5*, top view of pistillate bracts, × 7.5; *6*, fruits, × 7.5; *7*, portion of mature staminate spike, × 4.5; *8*, lower and upper views of staminate bracts, × 7.5; *9*, stamens, × 10.

FIG. 88. *Piper pulogense* C. DC.; *1–2*, leaves, × 0.5; *3*, portion of pistillate spike, × 5; *4–5*, fruits, × 7.5; *6*, stamens, × 7.5.

89. *Piper multistigmum* C. DC.; *1*, leaf, × 0.5; *2*, portion of pistillate spike, enlarged; *3*, fruits, enlarged.

90. *Piper spathelliferum* sp. nov.; *1*, leaf, × 0.5; *2*, portion of pistillate spike, × 5; *3*, two fruits and top view of stigmas, × 7.5; *4*, top view of bracts, × 10.

91. *Piper elliptibaccum* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bract, × 7.5; *3*, fruits, × 7.5.

92. *Piper clemensiae* C. DC.; *1*, leaf, × 0.5; *2*, pistillate bract, × 7.5; *3*, fruits, × 7.5.

93. *Piper nigrum* Linn. var. *trioicum* (Roxb.) C. DC.; *1–3*, leaves, × 0.5; *4*, portion of spike, × 7.5; *5*, top view of bract, × 7.5; *6*, stamens, × 10.

94. *Piper korthalsii* Miq.; *1–4*, leaves, × 0.5; *5*, pistillate spike, × 0.5; *6*, part of pistillate spike, with crowded submature fruits, × 0.5; *7*, portion of staminate spike, × 0.5.

95. *Piper korthalsii* Miq.; *1–5*, pistillate bracts, × 7.5; *6–8*, fruits, × 2.5; *9*, portion of staminate spike, × 7.5; *10–14*, staminate bracts, × 7.5; *15–17*, stamens in different views, × 10.

96. *Piper baccatum* Blume; *1–4*, leaves, × 0.5; *5*, portion of immature pistillate spike, × 7.5; *6*, mature pistillate spike, × 1; *7*, staminate spike, × 0.5; *8*, portion of staminate spike, × 7.5; *9*, stamen, greatly enlarged.

97. *Piper sarcopodum* C. DC.; *1–3*, leaves, × 0.5; *4*, pistillate spike, × 0.5; *5*, cupular receptacles and a fruit, × 7.5; *6*, staminate spike, × 0.5; *7*, cupular receptacle with stamens, × 7.5; *8*, stamens, greatly enlarged.

98. Leaves of: *1–3*, *Piper celtidiforme* Opiz; *4–5*, forma *luzonense* (C. DC.) comb. nov.; *6–7*, forma *usteri* (C. DC.) comb. nov.; *8–9*, forma *tubuanense* forma nov., all × 0.3; *10*, var. *vaginans* var. nov., petiole, base of lamina, and young pistillate spike, × 1.

99. *Piper celtidiforme* Opiz; *1*, pistillate bracts, × 10; *2*, stigmas, × 10; *3–4*, fruits, × 7.5; *5*, top and side views of staminate bracts, × 10; *6*, stamens, × 10.

100. *Piper catubigense* Merr.; *1–3*, leaves, × 0.5; *4*, pistillate bract, × 10; *5*, fruits, × 7.5; *6*, top and side views of staminate bracts, × 10; *7*, stamens, × 10.

101. *Piper penninerve* C. DC.; *1–3*, leaves, × 0.5; *4*, top and side views of pistillate bracts, × 10; *5*, fruits, × 7,5; *6*, different views of seeds, × 7.5; *7*, top and side views of staminate bracts, × 10; *8*, stamens, *a*, before dehiscence; *b*, after dehiscence, × 10.

102. *Piper villirache* C. DC.; *1–2*, leaves, × 0.3; *3*, leaf base, × 0.3; *4*, top and side views of pistillate bracts, × 6.5; *5*, fruits, × 5; *6*, top and side views of staminate bracts, × 6.5; *7*, stamens, × 6.5.

FIG. 103. *Piper begoniaefolium* (Blume) comb. nov.; *1*, fruiting branch, with young spike, × 0.5; *2*, mature spike, × 0.5; *3*, fruit, × 7.5; *4*, tips of bristles, × 40; *5*, bract adnate to the base of the pedicel, × 10; *6*, *a*, stamens and bract; *b*, front view of stamen; *c*, back view of stamen, × 10.

104. *Peperomia reflexa* (Linn. f.) A. Dietr. var. *capensis* (Miq.) C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, portion of the spike, × 7.5; *3*, top and side views of bracts, × 10; *4*, fruits, × 10; *5*, detail of the apex of a fruit, × 40; *6*, stamens, × 40; var. *parvilimba* C. DC.; *7*, habit sketch of the plant, × 0.5.

105. *Peperomia pallidibacca* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, form of leaves, × 0.5; *3*, base of an immature spike, × 10; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

106. *Peperomia canlaonensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, portion of the spike, × 7.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, apex of a fruit, × 40; *7*, stamens, top and side views, × 40.

107. *Peperomia copelandii* sp. nov.; *1*, habit sketch of the plant, × 1; *2*, top and side views of the bracts, × 20; *3*, fruits in different views, × 20; *4*, top and side views of stamens, × 80.

108. *Peperomia recurvata* (Blume) Miq. var. *pilosior* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, stem, × 1.5; *3*, apex of a leaf, × 1; *4*, top view of bracts, × 10; *5*, fruit, × 10; *6*, side and top views of stamens, × 40; var. *longispica* C. DC.; *7*, habit sketch of the plant, × 0.5; *8*, fruit, × 10.

109. *Peperomia lagunaensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, form of leaves, × 0.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

110. *Peperomia laevifolia* (Blume) Miq.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, × 0.5; *3*, form of leaves, × 0.5; *4*, side view of ovary and bract, × 40; *5*, top view of bract, × 40; *6*, fruits, × 10; *7*, stamens, × 40.

111. *Peperomia pellucidopunctulata* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, top and side views of bracts, × 10; *3*, fruits, × 10; *4*, stamens, × 40.

112. *Peperomia agusanensis* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, fruiting branch, part of main stem, × 0.5; *3*, portion of spike, × 7.5; *4*, top and side views of bracts, × 40; *5*, fruits, × 10; *6*, stamens, × 40.

113. *Peperomia merrillii* C. DC.; *1*, fruiting branch, × 0.5; *2*, form of leaves, × 0.5; *3*, lower portion of the spike, × 7.5; *4*, top and side views of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

114. *Peperomia negrosensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, fruits, × 20; *3*, top view of bracts, × 80; *4*, top views of stamens, × 80.

115. *Peperomia mindorensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, portion of the spike, × 18.

FIG. 116. *Peperomia elmeri* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, top view of bracts, × 10; *3*, *a*, young fruit, × 10; *b*, stigma, × 40; *4*, fruits, × 10; *5*, stamens, × 40.

117. *Peperomia pellucida* (Linn.) HBK.; *1*, habit sketch of the plant, × 0.5; *2*, apex of a leaf, × 7.5; *3*, form of leaves, × 0.5; *4*, lower portion of spike, × 10; *5*, apical portion of spike, × 10; *6*, top and side view of bracts, × 40; *7*, fruits, × 10; *8*, stamens, × 40.

118. *Peperomia exigua* (Blume) Miq.; *1*, habit sketch of the plant, × 0.5; *2*, leaf and spike, × 7.5; *3*, top view of bracts, × 10; *4*, fruits, × 10; *5*, stamens, × 40.

119. *Peperomia marivelesana* C. DC.; *1*, habit sketch of the plant, × 1; *2*, side and top views of bracts, × 20; *3*, fruits, × 20; *4*, stamens, × 80.

120. *Peperomia tomentosa* (Vahl) A. Dietr. var. *carnosa* Miq.; *1*, habit sketch of the plant, × 1; *2*, form of leaves, × 1; *3*, side and top views of bracts, × 80; *4*, fruits, × 20; *5*, detail of stigma, × 80; *6*, stamens, × 80.

121. *Peperomia latibracteata* sp. nov.; *1*, leaves, × 0.5; *2*, detail of a portion of the spike, × 10; *3*, fruits, × 10; *4*, detail of stigma, × 40; *5*, stamens before dehiscence, × 40; *6*, stamens after dehiscence, × 40.

122. *Peperomia rubrivenosa* C. DC.; *1*, habit sketch of the plant, × 0.5; *2*, leaves alternately disposed, × 0.5; *3*, leaves in whorls, × 0.5; *4*, top view of bracts, × 10; *5*, fruits, × 10; *6*, stamens, × 40.

123. *Peperomia lanaoensis* C. DC.; *1*, habit sketch of the plant, × 1; *2*, a leaf, × 1; *3*, top view of bract, × 20; *4*, fruits, × 20; *5*, stamen, × 80.

124. *Peperomia rivulorum* C. DC.; *1*, habit sketch of the plant, × 1; *2*, top and side views of bracts, × 20; *3*, fruits, × 20; *4*, stamen, × 80.

PLATE 1. PIPER TRICHOPHLEBIUM SP. NOV.; TYPE.

PLATE 2. PIPER MEDINILLIFOLIUM SP. NOV.; TYPE.

PLATE 3. PIPER SIMILE SP. NOV.; TYPE. FEMALE PLANT.

PLATE 4. PIPER SIMILE SP. NOV. MALE PLANT.

PLATE 5. PIPER MELANOCAULON SP. NOV.; TYPE.

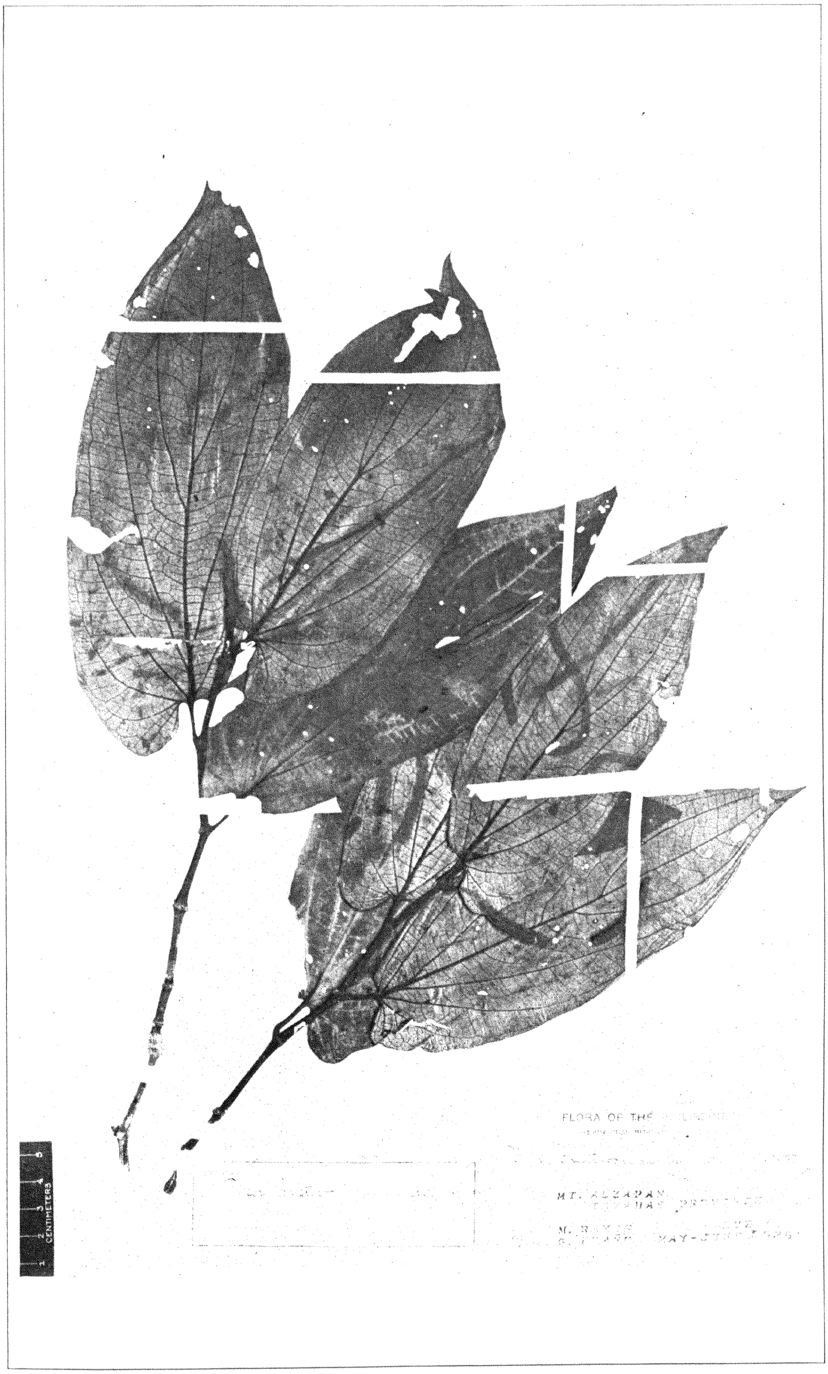

PLATE 6. PIPER ARISTOLOCHIPHYLLUM SP. NOV.; TYPE.

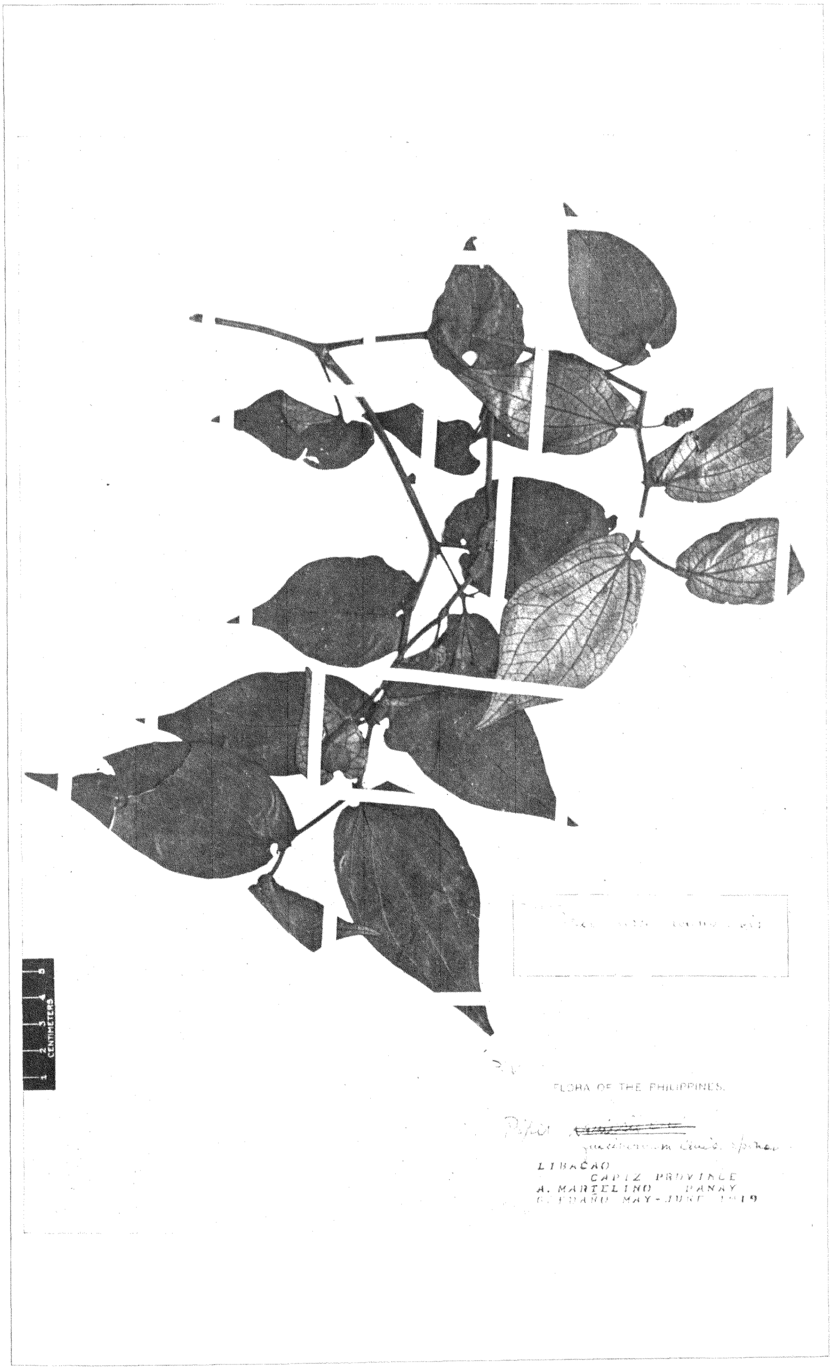

PLATE 7. PIPER FUSCINERVUM SP. NOV.; TYPE.

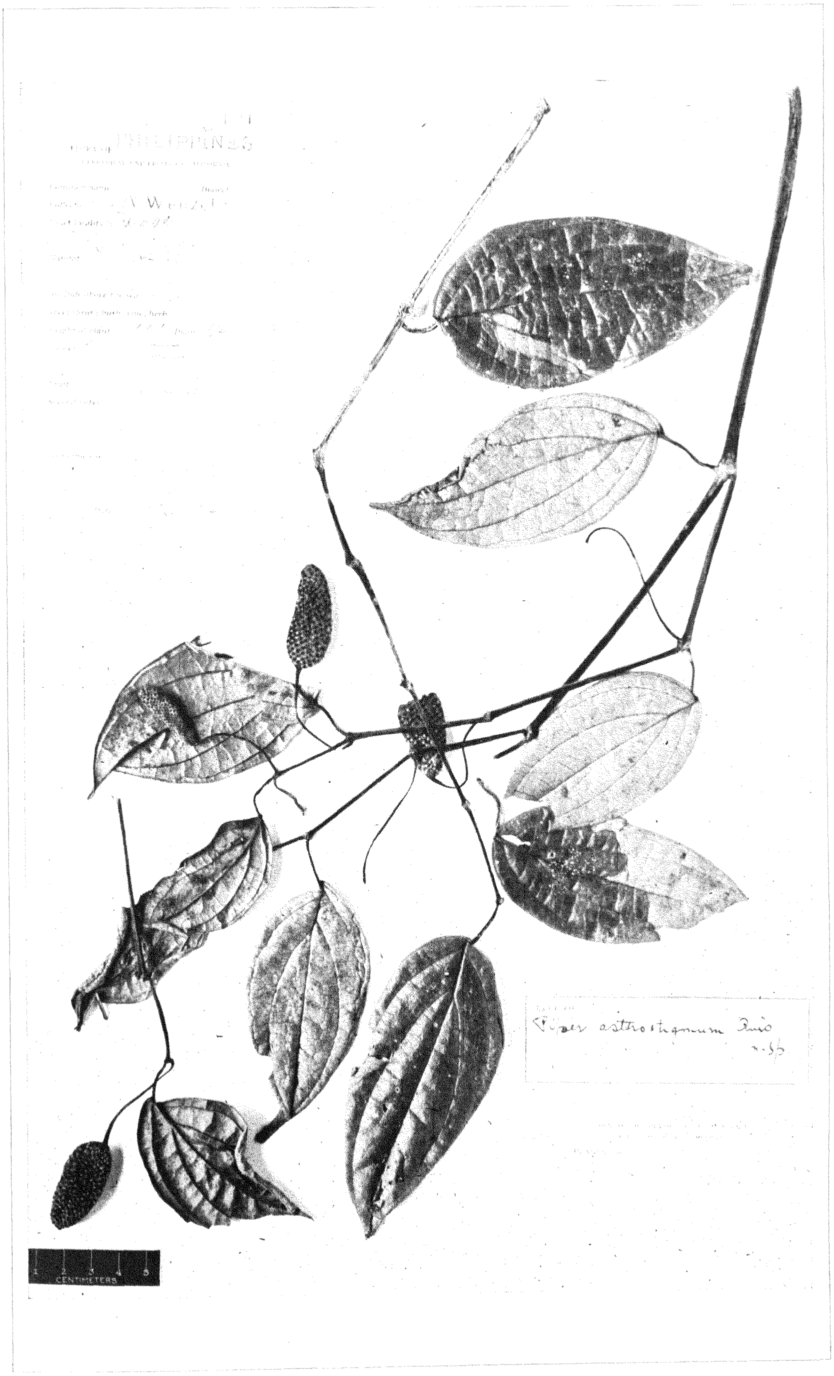

PLATE 8. PIPER ASTEROSTIGMUM SP. NOV.; TYPE.

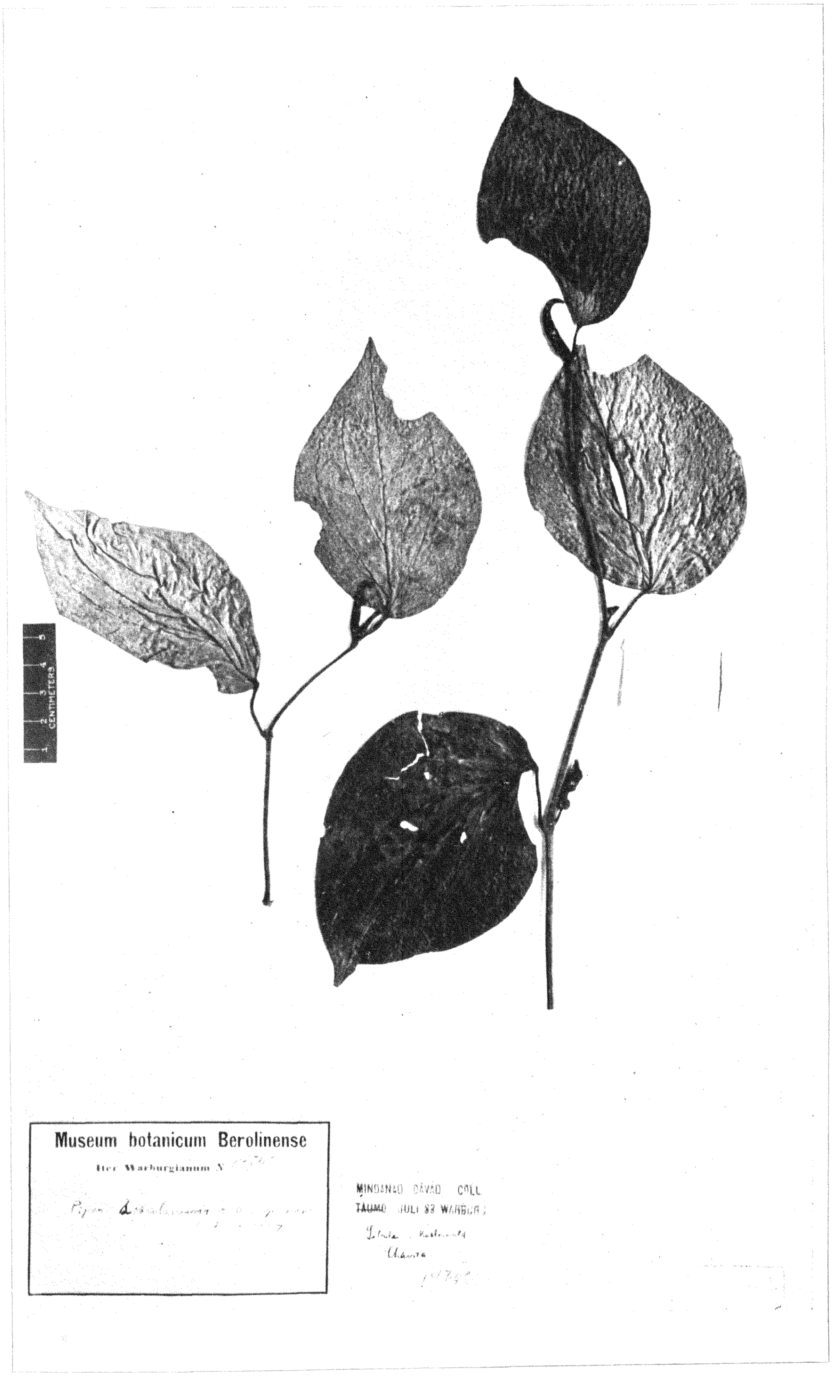

PLATE 9. PIPER SIBULANUM C. DC.; TYPE.

PLATE 10. PIPER PARONG SP. NOV.; TYPE.

PLATE 11. PIPER ENSIFOLIUM SP. NOV.; TYPE.

PLATE 12. PIPER CORDATILIMBUM SP. NOV.; TYPE.

PLATE 13. PIPER LONGIPEDICELLATUM SP. NOV.; TYPE.

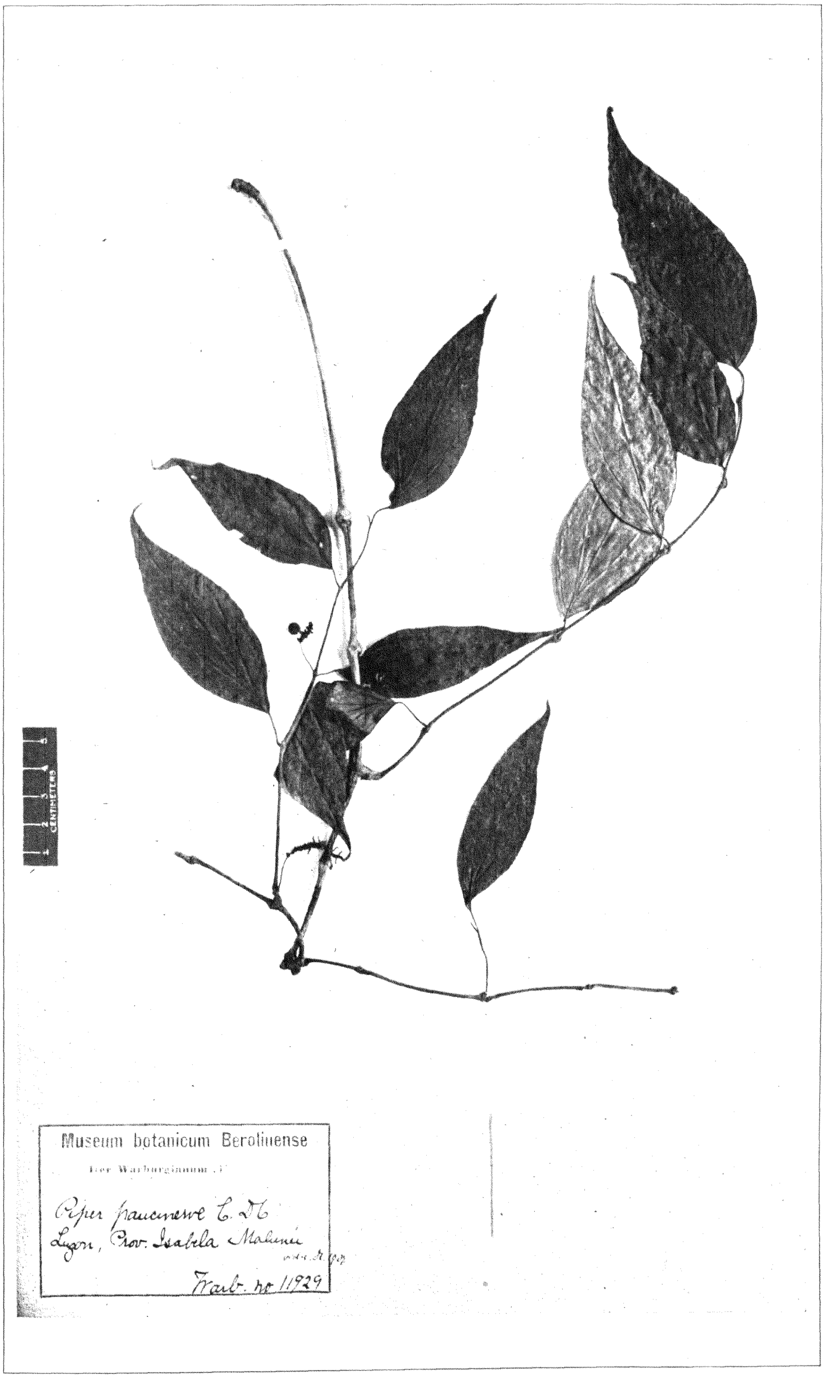

PLATE 14. PIPER PAUCINERVE C. DC.; TYPE.

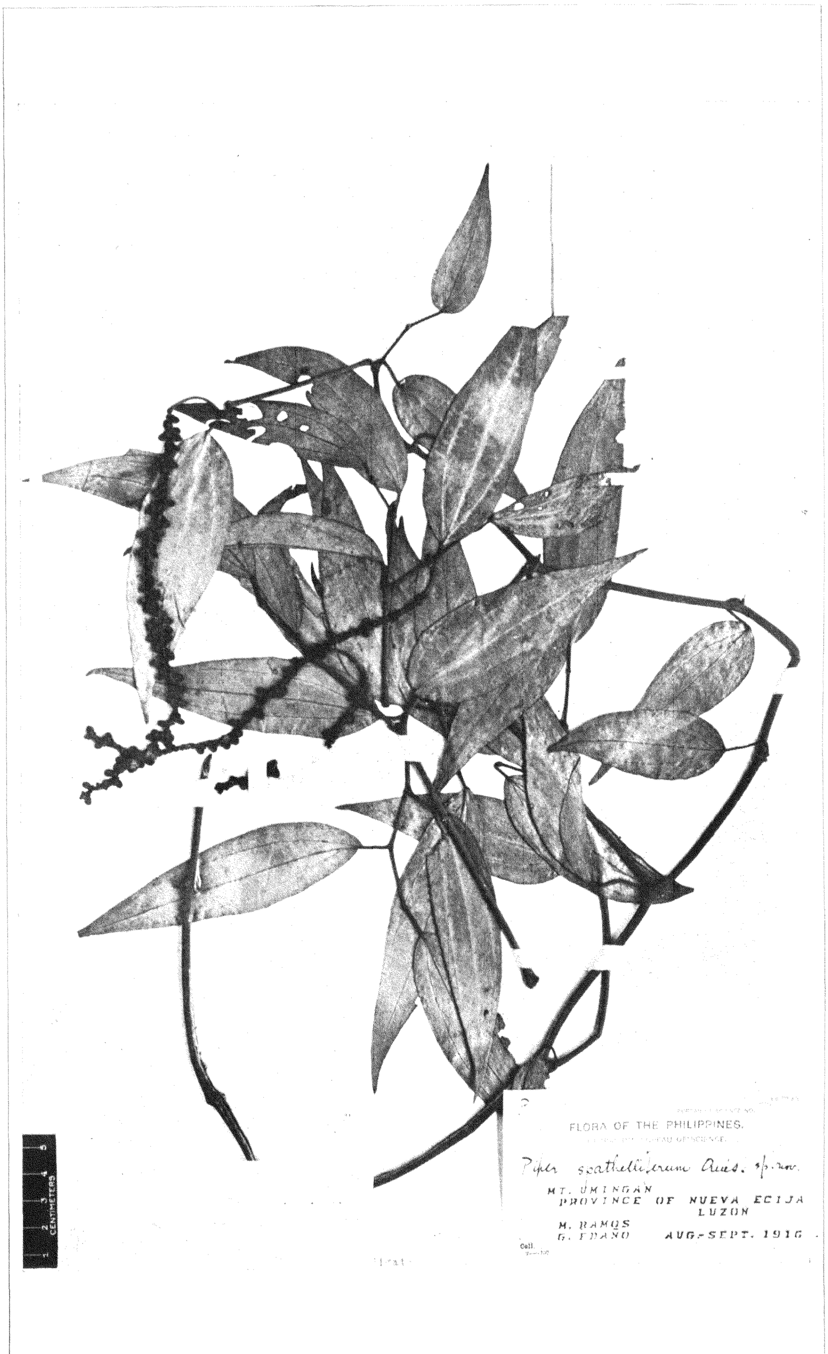

PLATE 15. PIPER SPATHELLIFERUM SP. NOV.; TYPE.

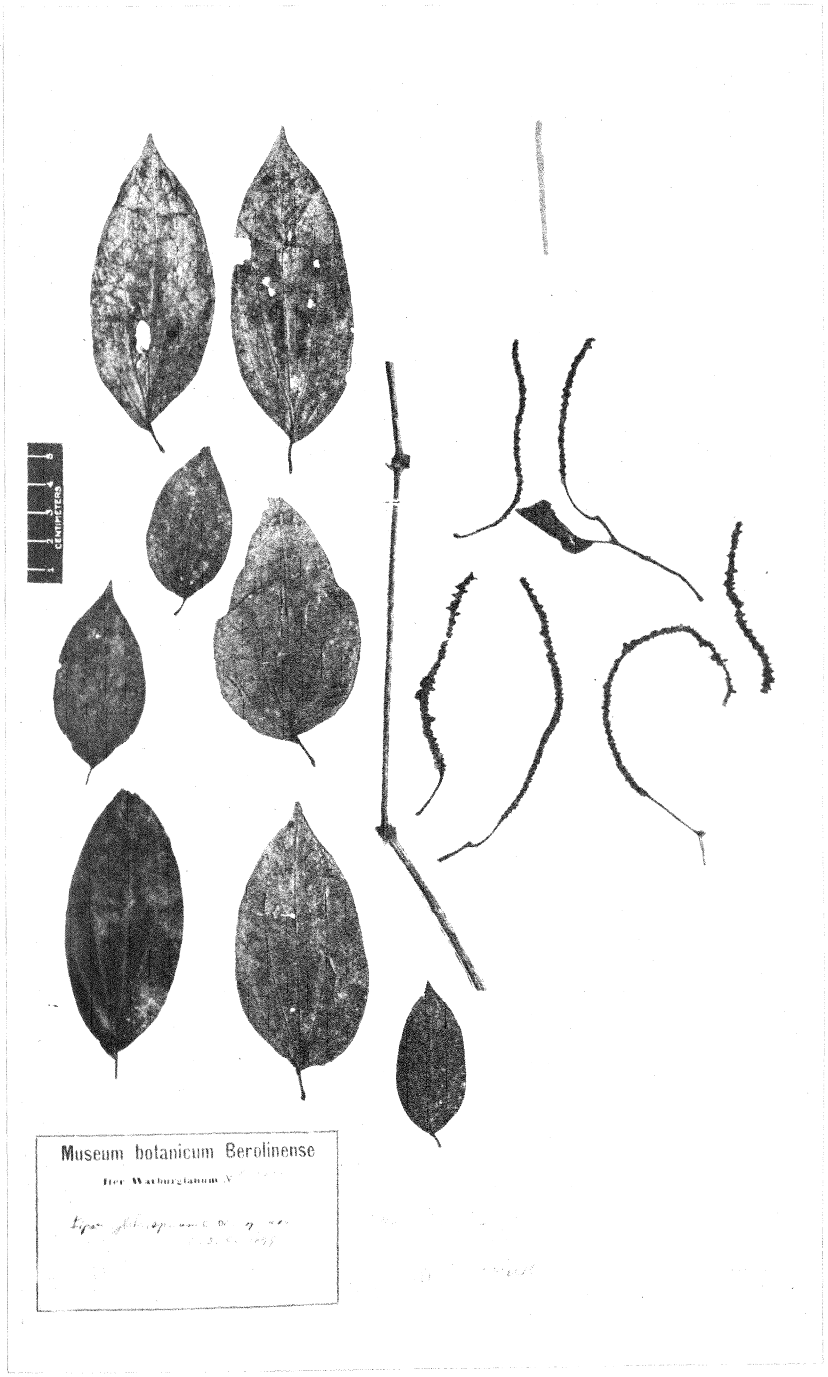

PLATE 16. PIPER NIGRUM LINN. VAR. TRIOICUM (ROXB.) C. DC. (TYPE OF PIPER GLABRISPICUM C. DC.)

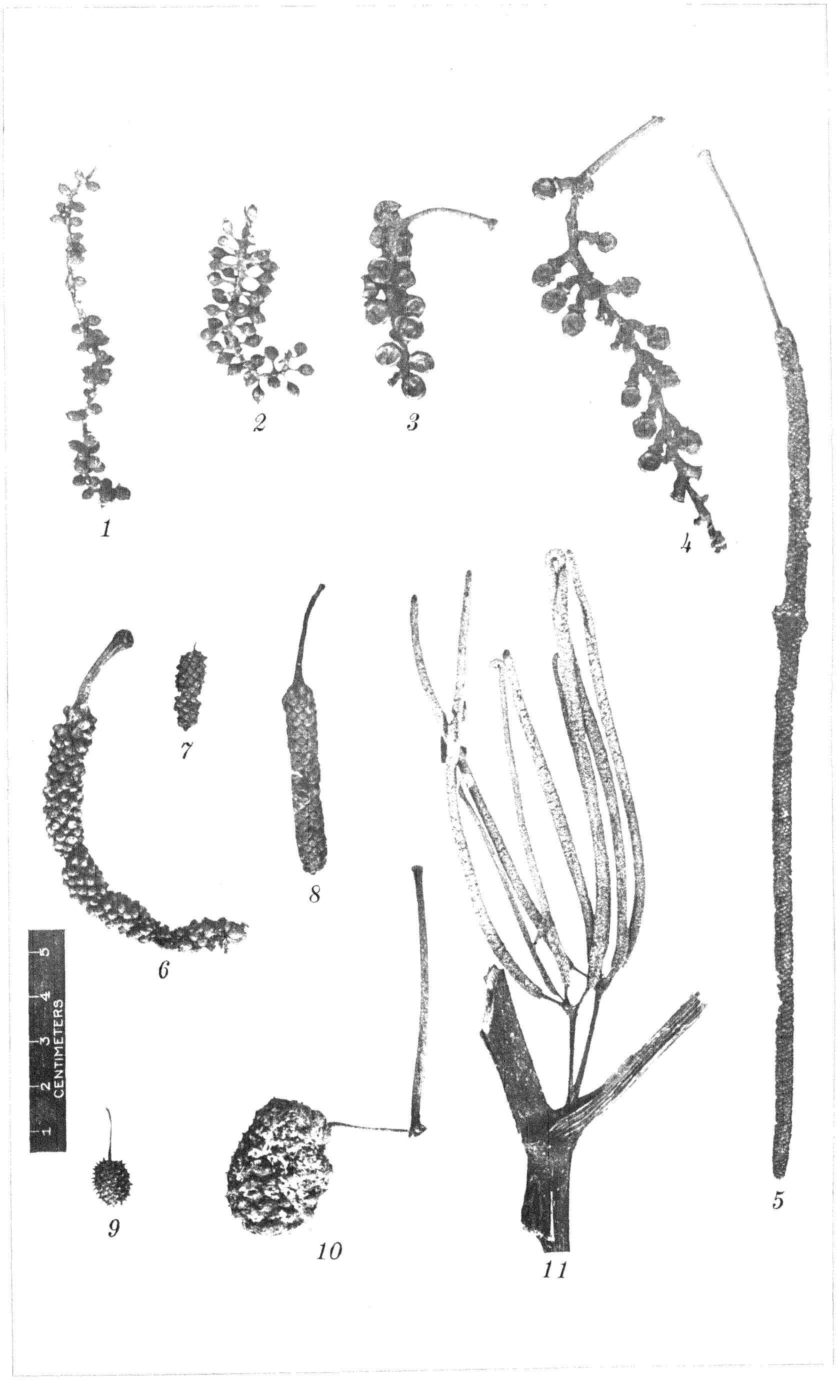

PLATE 17. TYPES OF PISTILLATE SPIKES.

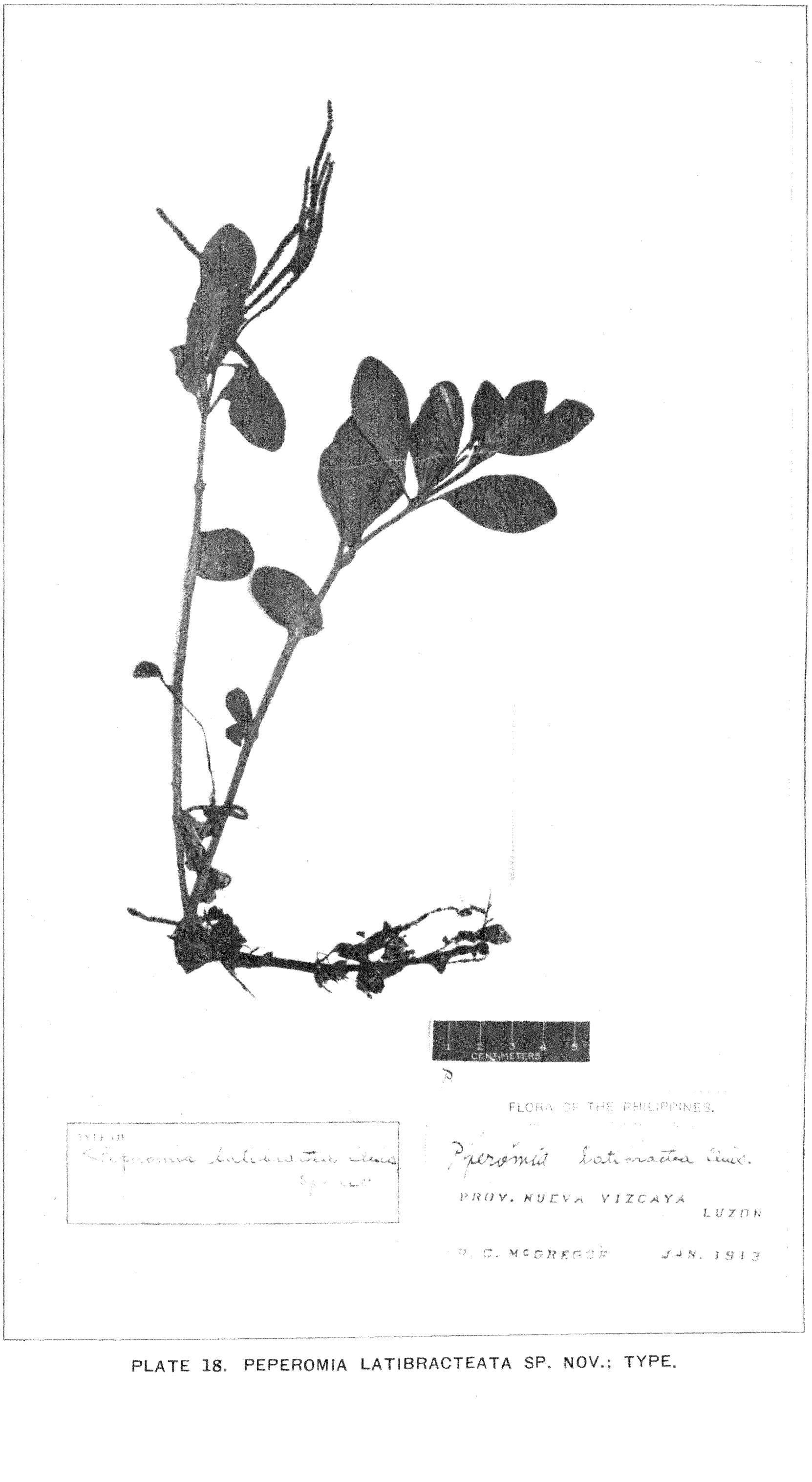

PLATE 18. PEPEROMIA LATIBRACTEATA SP. NOV.; TYPE.

PLATE 19. PIPER FIRMOLIMBUM C. DC.

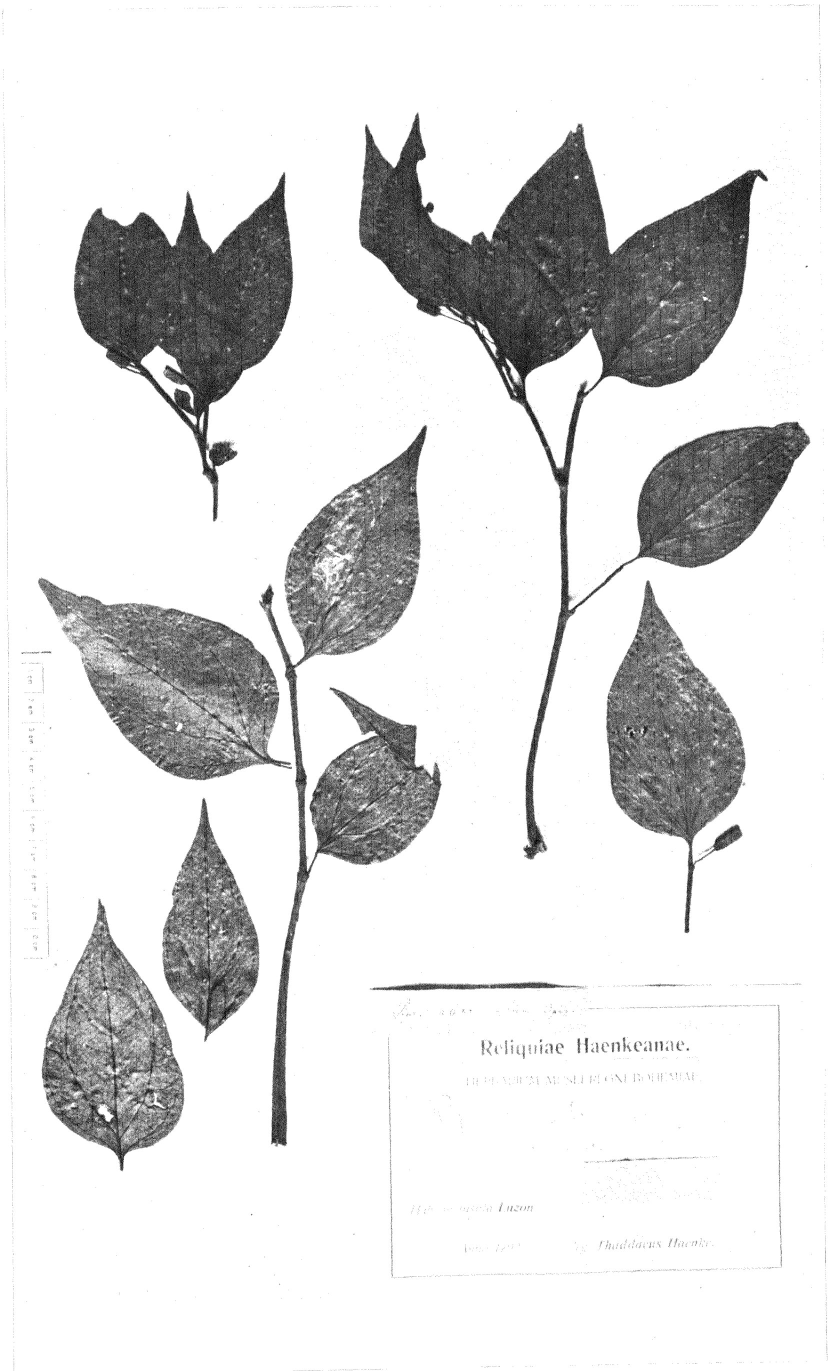

PLATE 20. PIPER ABBREVIATUM OPIZ; TYPE.

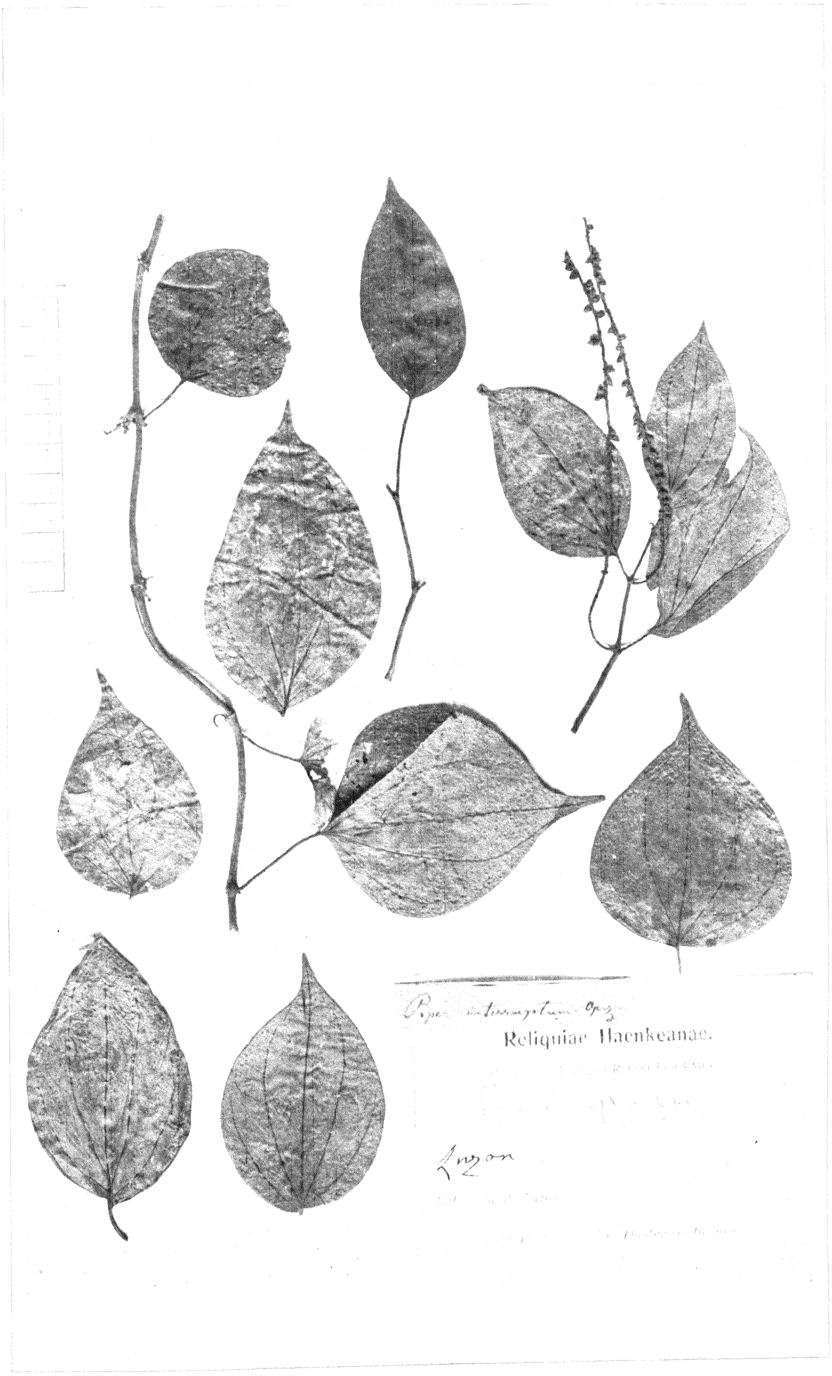

PLATE 21. PIPER INTERRUPTUM OPIZ; TYPE.

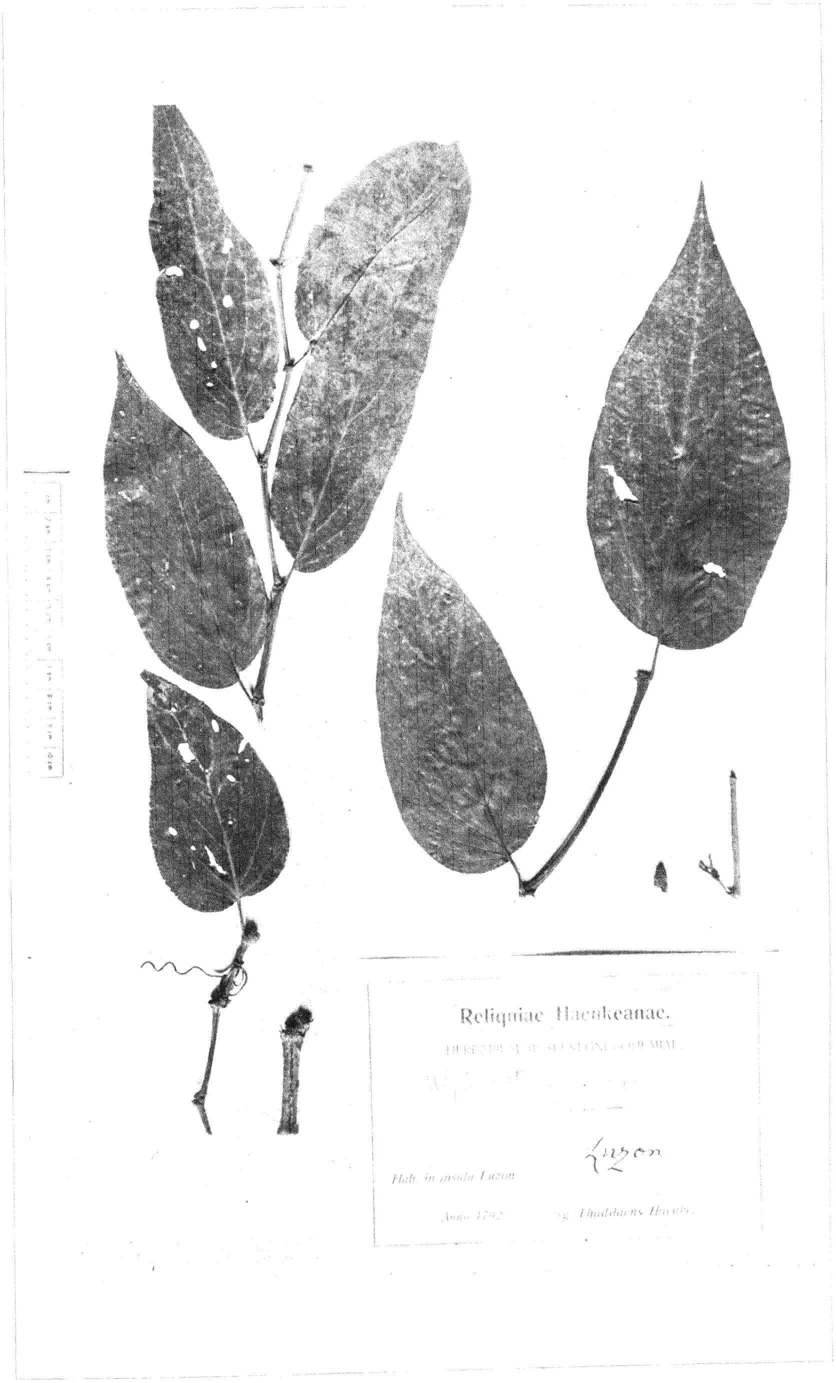

PLATE 22. PIPER CELTIDIFORME OPIZ; TYPE.

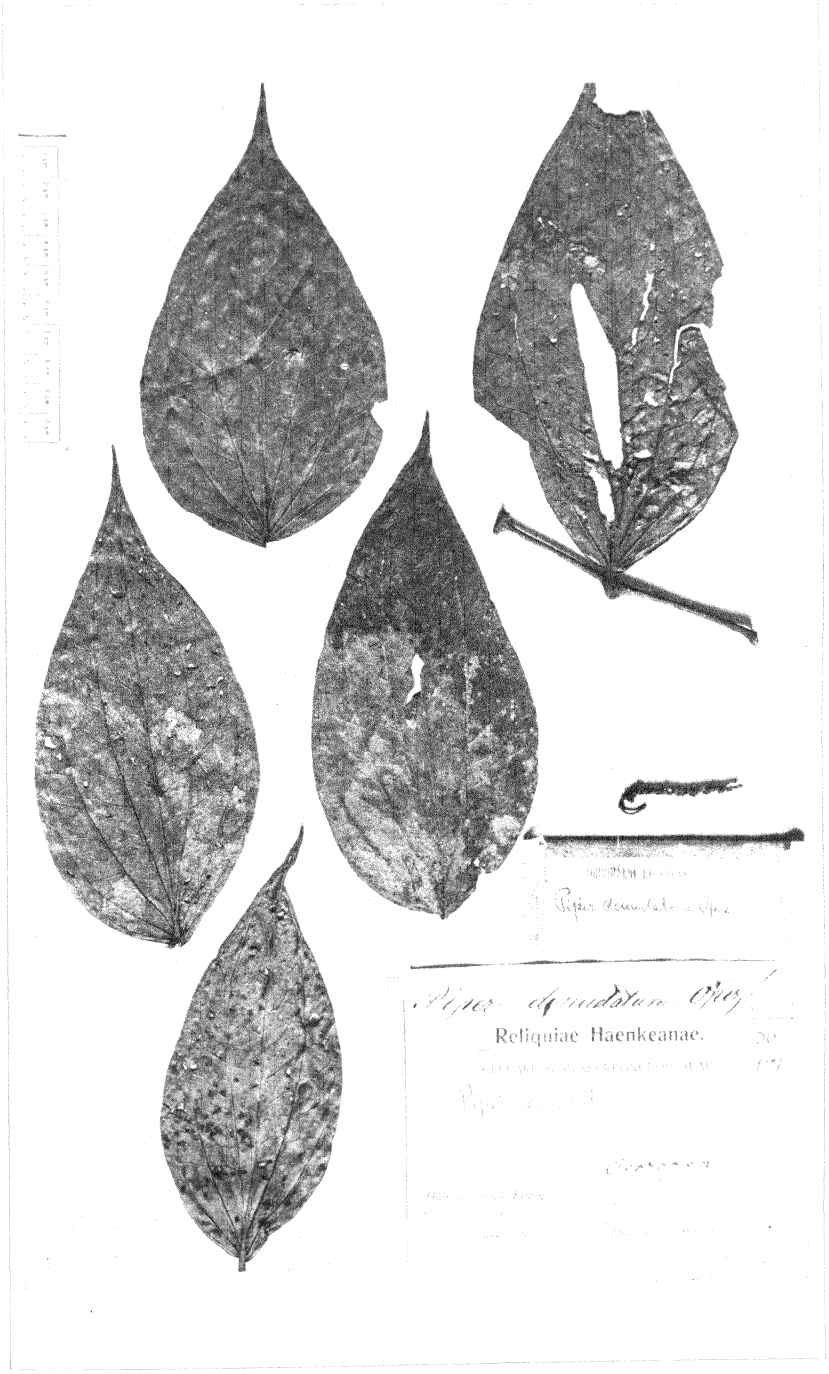

PLATE 23. PIPER DENUDATUM OPIZ; TYPE.

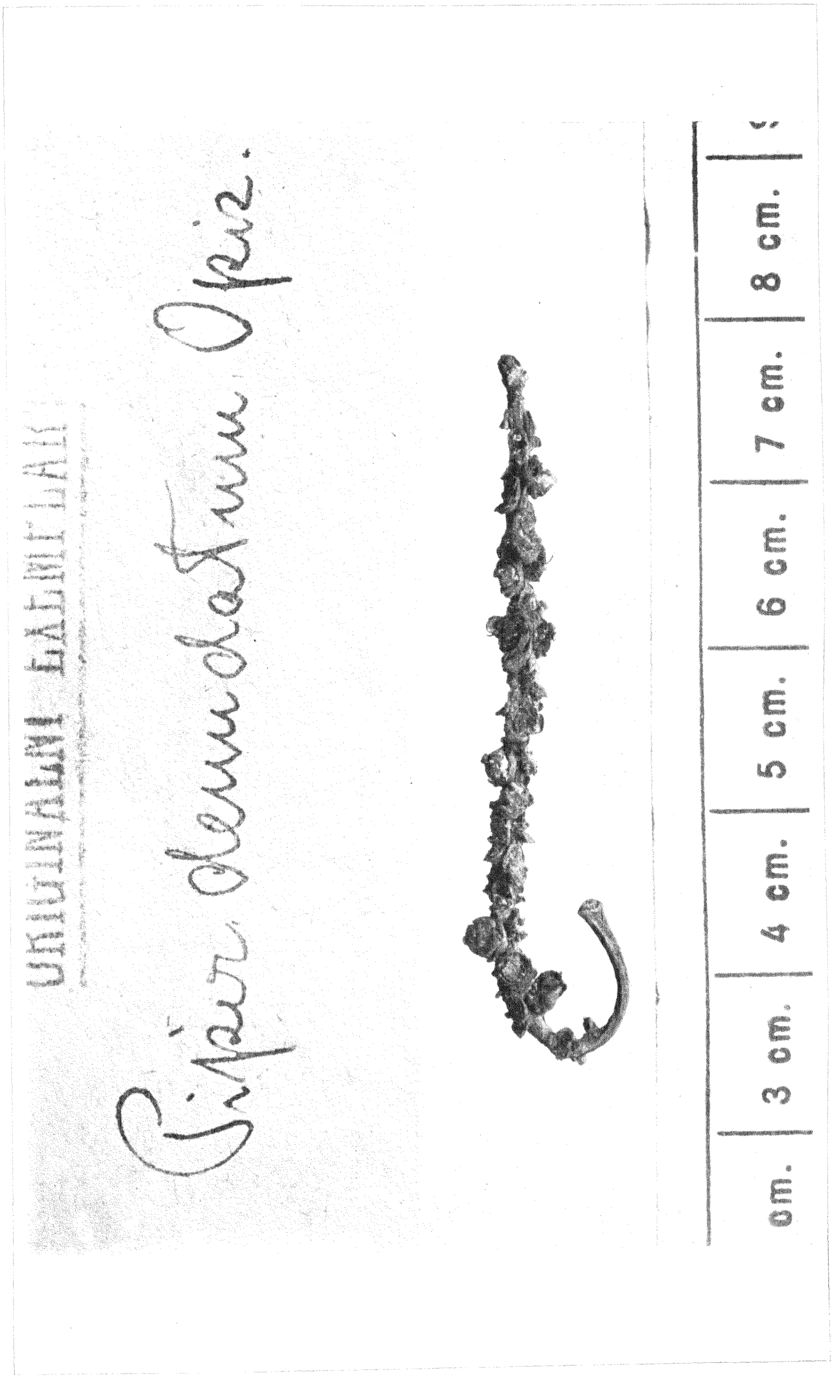

PLATE 24. PIPER DENUDATUM OPIZ. THE SPIKE CONTAINED IN THE POCKET, ENLARGED.

CONTENTS

	Page.
QUISUMBING, EDUARDO. Philippine Piperaceæ.......	1

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MORPHOLOGY AND CLASSIFICATION OF THE PHILIPPINE VARIETY OF ANOPHELES ACONITUS DONITZ, 1902, AND ANOPHELES MINIMUS THEOBALD, 1901 [1]

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ONE PLATE

Banks[2] included among Philippine Culicidæ *Anopheles funestus* Giles, 1900, and *A. minimus* Theobald, 1901, both collected by Capt. E. R. Whitmore in Camp Stotsenberg, Pampanga, and a species, *A. mangyana* Banks, 1906, collected by R. C. McGregor from Rio Baco, Mindoro. Bezzi [3] included "*Myzomyia rossi mangyana* Banks, 1906" and "*Myzomyia funestus* Giles, 1900" in his list of anophelines. *Anopheles febrifer* Banks,[4] with which Walker and Barber [5] obtained a high infection rate when it was artificially fed on gamete carriers, was obtained from Canlubang, Laguna. Christophers [6] lists *A. febrifera, A. mangyana,* and *A. flavirostris* Ludlow, all of Philippine origin, as synonyms of *A. minimus. Anopheles flavirostris* came from Camp Wilhelm, Tayabas, and was previously referred to by

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[2] Philip. Journ. Sci. 1 (1906) 977.

[3] Philip. Journ. Sci. § D 8 (1913) 305.

[4] Philip. Journ. Sci. § D 9 (1914) 405.

[5] Philip. Journ. Sci. § B 9 (1914) 381–439.

[6] Ind. Med. Res. Memoir No. 3 (1924) 50.

Miss Ludlow as *A. funestus,* dark variety.[7] Tiedeman,[8] in his discussion on Philippine anophelines, page 226, said: "Dyar, Christophers and Root have each very kindly identified specimens sent them. It is of particular interest to note that the *A. febrifer* Banks with which Walker and Barber worked is *A. minimus.*" Baisas[9] described *A. minimus* Theobald (typical) and three varieties of this species, all with branched (frayed) anterior inner clypeal hairs, which differed from each other according to the form (with or without branching) of the anterior external clypeal and the preantennal (posterior clypeal) hairs, but made no mention of *A. aconitus* Donitz, 1902. In the same paper, page 269, he gave an opinion of Root[10] based on a number of adults bred out from both the simple and branched-haired Philippine larvæ, sent to him by Mr. Mieldazis, of the Rockefeller Foundation. Root placed all Philippine *A. minimus* with branching of one kind or another of the clypeal and preantennal hairs under *A. funestus* var. *aconitus* and those without branches (except sometimes for slight apical bifurcation in the inner anterior clypeal and preantennal hair—Baisas) under *A. funestus* var. *minimus.*

From this brief review of the literature on the local *funestus* group, only Root (by reason of ample material examined and accurate information on the larvæ from which they were bred out by Baisas, two males with five females from typical and eight males with twelve females from atypical larvæ) considered the presence of a variety of *aconitus*[11] in the Philippines. He said, however:

> In order to do this latter [meaning creating a *funestus* var. *aconitus*], it would be necessary to amend the definition of variety *aconitus* so as to make[12] three dark spots on the 6th vein of the female and fringe spot at its

[7] Cited from Christophers, p. 50.

[8] Journ. Prev. Med. 1 (1927) 205–254.

[9] Monthly Bull. Phil. Health Service 7 (1927) 267–280.

[10] Personal communication to Dr. V. G. Heiser, of the Rockefeller Foundation, in 1926, a copy of which was kindly furnished me by Mr. J. J. Mieldazis.

[11] Baisas's record shows that these larvæ were collected from Pabanlag (Del Carmen, Pampanga) irrigation ditch in the middle of rice paddies. Water, slow flowing, and ditch full of grass, rather typical for this species in Java.

[12] The present series shows just over one-half of the females with three spots on the sixth vein (19 of 34, or 56 per cent) and 76 per cent with fringe spot at its tip.

tip, the main diagnostic characteristics of this variety with the apical golden half of the proboscis a variable character.

Records of routine dissections in the malaria-control laboratory of the Philippine Health Service of over 50,000 anophelines from malarious stations during the past two years, attribute all stomach and salivary-gland infections to *A. minimus* (excepting a heavily infected stomach of *A. vagus* Donitz, out of over 10,000 dissections of this species) omitting entirely *A. aconitus*, based on Baisas's opinion that the frayed-haired larvæ which Root considered *A. funestus* var. *aconitus*, were varieties of *minimus*. Furthermore, Root's ruling was not followed, due to the constantly black proboscis of the local *aconitus* and the frequently denuded wings [13] of the mosquitoes which made its differentiation from *minimus* difficult. In our past records of larval collections during surveys, or from streams in Paris green control areas, the typical and varieties of *minimus* were also entered under one name.

Anopheles minimus with malaria and *A. minimus* without it, in adjacent or similar localities with apparently all the existing conditions favorable for the propagation of the disease in both, were not infrequent in our past surveys, and this has not been clearly explained. Our failure to differentiate the local variety of *A. aconitus* from *A. minimus* may be one of the reasons. The data on hand on the incidence of *aconitus* among the supposed *minimus* larvæ collected from different stations are meager, but they vary from 0 to 30 per cent. The local and general importance of the systematic position of this group of Philippine mosquitoes is apparent, hence the present morphologic study.

I am indebted to Mr. C. M. Urbino, of the malaria-control division, Philippine Health Service, for the care he took in collecting the material during April, May, and June, 1929, mostly from Bulutong stream about 200 meters east of the laboratory at Tungkong Manga, Bulacan. The larval skins after pupation, which were originally preserved in alcohol, were permanently mounted on slides with Berlese's fluid. The adult mosquitoes, which carried the serial numbers of their respective skins, were pasted with shellac solution on cardboard wedges. Of the 241 larval skins examined, 73 skins, or 30 per cent, had frayed an-

[13] The specimens had to be transported by automobile on bad roads from stations 10 to 33 kilometers from the laboratory. It is hoped that the recent transfer of the laboratory to the field will help matters much.

terior internal clypeal hairs (*A. aconitus*); the remaining 168 had simple hairs. For morphologic correlation 65 skins of *A. aconitus*, 155 skins of *A. minimus*, and their corresponding adults were used, with 37 per cent of the former and 39 per cent of the latter, males. Of the females, 34 *aconitus* and 65 *minimus* were compared.

TABLE 1.—*Showing comparative morphology of the larval skins of Anopheles aconitus and A. minimus.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Skins examined.	Number and per cent.	Skins examined.	Number and per cent.
Anterior internal clypeal hairs	73		168	
With simple hairs		0		168
Do ... per cent		0		100
With frayed hairs		73		0
Do ... per cent		100		0
Anterior external clypeal hairs	30		36	
With simple hairs		20		33
Do ... per cent		67		92
With forked hairs		10		3
Do ... per cent		33		8
Posterior clypeal hairs	63		114	
With simple hairs		4		107
Do ... per cent		6		94
With forked hairs		59		7
Do ... per cent		94		6
Chitinous islets	72		133	
With islets		70		2
Do ... per cent		97		2
Without islets		2		131
Do ... per cent		3		98
Occipito-clypeal pattern	32		51	
With O-shaped pattern		29		8
Do ... per cent		90		16
With U-shaped pattern		3		43
Do ... per cent		10		84

LARVÆ

1. For convenience, all larvæ of this series with frayed or branched anterior internal clypeal hairs are classified as *A. aconitus*. In skin 637, included in the table, these hairs are distinctly branched.[14] Those with simple anterior internal clypeal

[14] An adult male with interrupted basal costa, no pale fringe at the tip of sixth vein and two spots on sixth and basal spot on third vein, was bred from the specimen.

hairs are classified *minimus*. No apical bifurcation of this hair as noted by Baisas was seen in the series. It may be stated that Strickland's[15] description of the larva of *minimus* gives this hair as being simple (p. 150), but his Plate 11, fig. 9, *a*, depicts apical bifurcation in both hairs.

2. Bifurcations, either apical or basal, of the anterior external clypeal hairs of *aconitus* are usually unilateral, but those with three or more branches are bilateral. In the larval skins examined the mouth brushes are always extended and obliterate these hairs. To expose them the occipital chitinous plate, which is usually disarticulated, is separated from the head, placed ventral side up, and with care and fine-pointed needles the brushes can easily be detached, leaving the anterior external clypeal hairs attached to the clypeus in most cases. Should they fall off, their recognition even if simple is not difficult, if care is taken that they be not confused with a pair of simple but bent, stout lip hairs located ventrally and anterior to the anterior internal clypeal hairs.

3. Branching of the posterior clypeal hairs of *aconitus* which is bilateral (more frequently with three or four branches than two) has been found to be just as important diagnostically as the simple hair (excepting rare unilateral bifurcation) in *minimus*.

4. By "chitinous islets" (Plate 1, fig. 1) is meant the pair of tiny elliptical (sometimes slit-shaped when on edge) dark brown to black plates of chitin in the integument of the dorsum of the first seven abdominal segments of *aconitus* larvæ (in some specimens they are not visible in the first three segments when the tergal plates are poorly developed). They are best seen on a dorsoventral position of adult living or mounted larvæ, posterior to the tergal plates, one on each side of the median line, forming a triangle with the dark pigmented area in the middle of the plate[16] (except the eighth). Because of the transparency of the colorless larval skin surrounding them, they appear like pairs of minute chitinous "islands." In skins they are even more distinctly visible than in larvæ, but due to telescoping of the segments they frequently appear to be in the tergal plates themselves. They are always darker than the area on the plate. They measure about 10 μ by 40 μ (longest diameter transverse), and under a high power show the same laminations that are

[15] Ind. Journ. Med. Res. 12 (1924) 145–152.

[16] Like the holes for the eyes and nose of a Hollowe'en pumpkin.

seen on the edge of the tergal plates. As far as I can find out, these structures have never been described before in *aconitus* larvæ; although Strickland's plate 12, a microphotograph of an *aconitus* larval skin, shows them quite clearly in segments 4, 5, and 7. They seem to show a certain difference in the degree of chitinization between the two species. The few exceptions in which they are not seen in *aconitus* are in skins where the general chitinous frame is pale and appears thin. Conversely, the two exceptions in *minimus* show marked development of their chitins.[17] The material examined shows these "chitinous islets" to be important structures in differentiating Philippine *aconitus* and *minimus* larvæ, fig. 2, and larval skins, even when the head capsule is missing.

5. When the occipital chitinous plate is separated from the head, pigmented areas are revealed which are arranged in a more or less definite "occipito-clypeal pattern" and which, as far as the material examined is concerned, also show a fairly constant difference between *aconitus* and *minimus*, figs. 3 and 4; the former giving an O-shaped and the latter a U-shaped pigmented area in the anterior half of the pattern. In some instances (10 per cent) a lightly pigmented *aconitus* shows a U and conversely a deeply pigmented *minimus* an O or Θ pattern (16 per cent). Apparently, this larval character has also been overlooked before, although it may be of some value in closely allied species.

6. The frequent loss of the internal occipital (transutural) hairs precludes the examination of a good number in the present series, but examination of many larvæ shows a constant difference in their branching; *aconitus* with simple, relatively long, basal branching of three or four, while *minimus*, with basal bifurcation into two main trunks, which later give off two to five short branches each.

7. The antepalmate hairs on the second abdominal segment show, as a rule, apical branching in *aconitus* and basal in *minimus*.[18] This hair is often misplaced or lost in mounting larval skins. They are better seen on larvæ mounted in Gater's fluid.

[17] The absence of "chitinous islets" in a very small number of *aconitus* and their presence in a similar number of *minimus* may be a manifestation of the result of interbreeding between the two. The same may be true with other larval structures and the markings in the adult.

[18] Mr. F. E. Baisas has kindly called my attention to this important difference.

8. The posterior border of the second, and frequently the third, tergal plate in *minimus* is always concave or indented while in *aconitus* it is convex.*

TABLE 2.—*Showing comparative morphology of the adults of Anopheles aconitus and A. minimus.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Mosquitoes examined.	Number and per cent.	Mosquitoes examined.	Number and per cent.
Proboscis ♀ (distal half)	34		65	
With black distal half		34		50
Do per cent		100		77
With slightly flavescent distal half		0		15
Do per cent		0		23
Palps ♀ (the two apical white bands)	34		65	
With bands equally wide		18		62
Do per cent		53		95
With distal band wider		16		3
Do per cent		47		5
Costa ♂ and ♀ (basal or proximal third)	62		153	
With interrupted proximal third		54		79
Do per cent		87		52
With proximal third all black		8		74
Do per cent		13		48
Fringe ♂ and ♀ (pale spot at apex of sixth vein)	63		152	
With pale spot		42		11
Do per cent		67		8
Without pale spot		21		141
Do per cent		33		92
Third longitudinal vein ♂ and ♀ (basal spot) [a]	64		155	
With basal spot		46		144
Do per cent		72		93
Without basal spot		10		3
Do per cent		15		2
Sixth longitudinal vein ♂ and ♀ (No. black spots)	65		155	
With two spots		38		122
Do per cent		58		80
With three spots		23		6
Do per cent		35		4

[a] The basal black spot, as a rule, is longer and darker in *minimus*.

ADULT

1. The proboscis of the present series is all black in *aconitus*, and 23 per cent slightly flavescent distal half in *minimus*, usually laterally and inferiorly.

2. In about 50 per cent of *aconitus* the two broad apical white bands of the palps are equal in width, the intermediate black

* An observation by Mr. A. G. Laurel. In the case of the two *minimus* with "chitinous islets" their second tergal plates showed this indentation.

band very narrow. In the others the terminal white is slightly broader. The intermediate black is as wide or even wider than the second white in a number of them. In *minimus* these bands (two apical white) are usually equal. The apical black band and proximal white in *aconitus* are more frequently wider than those in *minimus*. The apical black band is frequently pale brown to gray in *aconitus*, but as a rule it is black in *minimus*. Specimen 307 of *aconitus* shows no apical black band at all.

3. In 31, or 91 per cent, of 34 female *aconitus* the base of the costa is interrupted; in 28, or 43 per cent, of 65 female *minimus* the base is interrupted. In about 20 per cent of *aconitus* with interrupted basal third of the costa, two pale spots caused the interruption, a condition not observed in *minimus*.

4. The pale spot on the fringe at the tip of the sixth vein is present in 67 per cent of *aconitus*, (male and female), and only 8 per cent of *minimus* (male and female). This spot is often difficult to see in the males. Among 34 female *aconitus* the spot is clear in 26, or 76 per cent; and of the 65 female *minimus*, it is clear in 9, or 14 per cent.

TABLE 3.—*Important differential characters of female Anopheles aconitus and A. minimus, wings only.*

Anatomical structures.	*A. aconitus.*		*A. minimus.*	
	Mosquitoes examined.	Number and per cent.	Mosquitoes examined.	Number and per cent.
Costa (basal or proximal third)	34		65	
With interruption		31		28
Do per cent		91		43
Without interruption		3		37
Do per cent		9		57
Fringe (pale spot at apex of 6th vein)	34		65	
With pale spot		26		9
Do per cent		76		14
Without pale spot		8		56
Do per cent		24		86
Sixth vein (number of black spots)	34		65	
With three spots		19		4
Do per cent		56		6
With two spots		15		61
Do per cent		44		94

5. No marked difference is noted in the amount of white area in the third vein of both species although the tendency is longer white in *aconitus*. Neither is the difference in the incidence of the dark basal spot in both species significant, 72 per cent for

aconitus (male and female) and 93 per cent for *minimus* (male and female). Four specimens with all white and eight with basal spots only are recorded in the *aconitus* series, and three all white and eight with basal spots only in *minimus*. The basal spot of *minimus* is usually darker and often longer than that of *aconitus*. In a few instances there are noted two dark basal spots in the third vein of *minimus* but none in *aconitus*.

6. The difference in the number of black spots on the sixth vein of both species is significant. In female *aconitus*, 56 per cent had three spots and 44 per cent two spots. Of 65 female *minimus*, 61, or 94 per cent, had two spots. In both species, when two spots are present, the apical (distal) occupies about all of the apical half of the vein. In about 7 per cent of *aconitus* and 16 per cent of *minimus*, the two spots on this vein are confluent or almost so, and more often in males than in females.

7. The anterior branch of the fifth vein in six specimens among one hundred fifty-five adult *minimus* is mostly black; that is, the middle black spot is continuous with the apical one. They are all without the pale fringe spot at the tip of the sixth vein, three are with interruption at the base of the costa and three without.

8. There is no difference noted between the two species in the buccopharyngeal armatures of the females or the male genitalia.

COMMENTS

Strickland suggested a standard practice (p. 152) giving distinct anophelines varietal rank if their larvæ are identical, and specific rank if their larvæ are different. After a careful consideration of their larval and adult characters, he sank *minimus* under *funestus* but maintained *aconitus* as a distinct species.

Root's [19] stand on the Philippine *funestus* group has already been given. This author [20] (1926) gave the following opinion (p. 68) in his studies on South American anophelines:

> I have taken the position that where well marked and constant differences existed in larval structure and male genitalia, it was proper to consider the two forms distinct species, even though no satisfactory characters for the separation of the adult females could be presented. This is my reason for describing *A. strodei* as a new species. Conversely, in the case of *A. braziliensis*, where the male genitalia and larvae are identical or practically so, I have considered the small, but definite differences in adult markings as deserving a varietal status.

[19] Root's stand was not offered as an authoritative ruling, but only an idea of the most satisfactory classification.

[20] Am. Journn. Hyg. 6 (1926) 684–717.

Carter [21] (1924) agreed with Strickland (p. 33) in the identity of *Anopheles minimus* and *A. funestus listoni* but retained *aconitus* as a variety of *funestus* due to the occurrence in Ceylon of an "intermediate form" of larva between *funestus* and *aconitus*. He said (p. 48) that this form is the commonest in Ceylon and the clypeal and preantennal hairs usually all possess a few short branches arising at intervals along the stem. In his synopsis (p. 55) he included the "intermediate form" with the typical (simple-haired) *funestus* var. *listoni*. For *funestus* var. *aconitus* he gave "inner and outer clypeal hairs with more numerous short branches, preantennal hair branched (5 to 6 divisions) from the base." In his description of the adult (pp. 33–34) Carter did not mention what sort of an adult emerged from the "intermediate form" of larva, but I take it as identical with adult *funestus listoni*. Carter also failed to mention whether or not the adults he described were bred out from larvæ whose skins after pupation were used in his larval description.

An application of Strickland's "standard practice" and Root's opinion to Carter's Ceylon material will necessarily give rise to two identical adult mosquitoes with different names, *A. funestus listoni* and a new name for the "intermediate form" following the former author; and two different adult mosquitoes, *funestus* var. *aconitus* (larva with branched clypeal hairs) and *funestus listoni* (larva with simple clypeal hairs) identical following the latter. The puzzle may be solved by both Strickland and Root, either hoping that an unavoidable accident crept in Carter's manipulation of his material whereby an "intermediate form" adult was credited to a typical *listoni* larva, or conclude that the Ceylon "intermediate form" is not *listoni* but a variety of *aconitus* something like the one in the Philippines with the proboscis all black, etc., and not readily distinguishable from adult *listoni*. If Carter's observation was correct, Strickland and Root will have to reconsider their stand. I am inclined, however, to agree with the majority. As for the status of the Philippine species, the following considerations will determine.

1. Christophers and Carter define female *aconitus* as (1) distal half of proboscis always golden; (2) vein 6 with three dark spots; (3) fringe spot at vein 6; (4) vein 3 extremely pale, usually without dark spot towards base; (5) base of costa with about

[21] Ceylon Journ. Sci. § D 1 (1924) 29–59.

equal frequency with or without a pale interruption. Swellengreble[22] described in a series from Mandailing, Java, what he considered to be atypical *aconitus* with its proboscis all black; palp with two terminal white and intermediate black bands equally broad; base of third vein pale; sixth vein with two black spots and no pale fringe spot at its tip. Strickland, however, (p. 148) believed them to be, "a series of *minimus* with only one character, either the palps or the 3rd vein atypical and all other characters typical rather than *aconitus* with only one character, the 3rd vein typical and all other characters atypical." Strickland did not mention if the larva of Swellengreble's atypical *aconitus* were known, but I take it that it should have the *minimus* type of anterior internal clypeal hairs to make his standard practice consistent with his conclusion on the adult. Reference is not available if Swellengreble reared his adults from known larvæ or not. In their[23] article on larvæ, they described *A. aconitus* Donitz (p. 28) and a variety (p. 29), the latter (from Penjaboengan, Mandailing) having completely bald (not frayed) clypeal hairs (pl. 13, fig. 1). If Swellengreble's atypical adult came from the "bald" type of larva, Strickland's conclusion was right and Swellengreble's variety of *aconitus* larva must surely have been *minimus*.[24]

In the adult findings on the local *aconitus*, a certain percentage of them agreed with Swellengreble's mosquitoes (be they his atypical *aconitus* or typical *minimus*); namely, the black proboscis; basal spot of third vein absent in 15 per cent; 44 per cent with two dark spots on sixth vein and 24 per cent without pale fringe spots at its tip. Following Strickland's and Christophers's description of female palps typical of *aconitus* (two broad pale apical bands) the female palps of the local mosquito show 53 per cent agreement; vein 6 with three dark spots in 56 per cent; pale fringe spot opposite sixth vein in 76

[22] Cited from Strickland.

[23] Mededeelingen van Den Burgerlijken Geneeskundigen Dienst in Nederlandsch-Indie, Deel VI (1919).

[24] The more so when they said (p. 29), "the larva of M. minima comes quite close to this form but the filaments of the leaflets of the fans (palmate) are longer in the latter." Under Myzomiya minima (p. 30) they said: "In all particulars perfectly similar to the variety of M. aconita. The only difference to be detected is the length of the filaments of the leaflets of the abd. fans which is ½–⅗ of the length of the leaflet, whereas in aconita (variety) it is only 3/10, ⅖ at the utmost of this length. I am not sure whether this distinction always holds true."

per cent; third vein without basal black spot in 15 per cent; and base of costa interrupted in 91 per cent (uninterrupted, p. 148—Strickland). It is evident, therefore, that the principal departures of the Philippine *aconitus* from the classical definition of this species are the black proboscis and the dark spot (75 per cent) at the base of the third vein.

The larva of the local variety with fraying of anterior internal clypeal hairs agrees with Strickland's from Malaya and Assam, excepting in the anterior external clypeal which is forked or simple in the present series but frayed with this author. Our *aconitus* differs from the Javanese (p. 28) in the same way that Malayan and Assamese did. Ceylon *aconitus*, according to Carter, has definitely branched clypeal and preantennal hairs. All the other larval structures, however, in specimens from Assam, Malaya, Java, or Ceylon agree with those in Philippine specimens. Branched hairs in Ceylon and frayed in Malaya, Assam, and Java, giving rise to the same mosquito, is interesting to note. I have observed few larvæ with definite branching and 1 in 65 of the present series with, so far, no difference in the adult character. It looks as if in this group of mosquitoes, it is the presence or absence and not the branching, fraying, or its amount that counts.

ANOPHELES ACONITUS var. FILIPINÆ var. nov.

In conclusion, the local female adult *aconitus* has been shown to have characters in common with varying frequencies with the typical forms from Assam, Malaya, and Ceylon. The larvæ have also been shown to have most of the principal characters excepting the type of branching of the clypeal hairs. Therefore, it seems proper to accept Strickland's stand and Root's opinion that there is present in the Philippines a variety of *aconitus* whose larva is identical with the typical (with minor variations in the clypeal hair branching), but the adults of which manifest definite variations (black proboscis, etc.) from *aconitus* Donitz. Therefore, I propose to call the local mosquito *Anopheles aconitus* var. *filipinæ* var. nov. and not *funestus* var. *aconitus* Root. The female of this variety has the following outstanding characters: (*a*) Black proboscis; (*b*) costal interruption at basal third (when there are two interruptions it is surely *aconitus*); (*c*) pale fringe spot opposite the sixth vein; (*d*) sixth vein with two or three dark spots.

2. Strickland reduced *minimus* to *funestus* after showing by careful analysis of the female adult characters that the defini-

tions of *minimus* and *funestus* by Christophers, Edwards, and Ingram were inadequate,[25] their male genitalia identical (pp. 150–151) and because he could show that their larvæ and pupæ were also identical. The West African *funestus* he examined was furnished him by Scott-Macfie and Ingram (p. 150), while his *minimus* larvæ were from Assam. Strickland's description of *minimus* (*funestus*) larvæ tallies with the characters of larvæ from the Philippines. The adult characters of the local *minimus* also agree with Strickland's definition of *funestus* except the occasional pale fringe spot (14 per cent) at tip of sixth vein in the local female[26] *minimus*, but never found in his. It is but logical to concur with him, and that the Philippine *minimus*[27] should be called *A. funestus* (Giles, 1900) emended by Strickland, 1924, and not *funestus* var. *minimus* as suggested by Root. I have arrived at my present conclusions in complete agreement with Strickland (pp. 151–152),

> that the ontogeny of mosquitoes as of any other creatures betrays their phylogeny seems to be often ignored by systematists. Carter (in Byam and Archibald) for instance, in his schedule of anopheline species has relegated to a footnote the species *novumbrosus* and *similis* unworthy companions to the *haute elite* of the family, on the ground that the former are *mainly determined by larval structure.* This seems to me a sufficient reason for giving them more definite status than any species based on only adult characters and the feeling is born out by Christophers' recent discovery which he kindly allows me to mention that *novumbrosus* as determined by the male genitalia is very remarkably distinct.

For differential characters in the wings of the local female *aconitus* and *minimus* (*funestus*), see Table 3.

A restudy of the *funestus-aconitus* group (or any other similarly allied groups of mosquitoes) as they occur in different countries with the practice of using only those adults whose original larval skins are preserved and described will be the only means of avoiding confusion and defining criteria for their

[25] Strickland, page 149, said that in addition to his own Assam *minimus*, he studied *funestus* and *minimus* from Sierra Leone, the Gold Coast, Zanzibar, and Western India. The specimens were furnished by Christophers and by Scott-Macfie and Ingram.

[26] Nine of 65 females had distinct pale spots. Although the chance of error in numbering and mounting is small, I do not ignore its possibility.

[27] J. A. Sinton (July 30, 1928) writes me in agreeing with our identification of *A. minimus* Theobald, on specimens sent to him, that the absence of interruption on the inner quarter of the costa, as described in typical minimus, makes them resemble Iyengar's *varuna*.

varietal or specific rank. I failed to notice any mention of this procedure in Carter's work, and in Iyengar's [28] on *A. varuna* Iyengar, 1924 (*A. minimus* var. *varuna* Christophers, 1924).

It is hoped to extend the present study, particularly on materials from different localities, in order to confirm or amend the present conclusions. Pending further observations to show the contrary, all frayed or branched Philippine larvæ heretofore called *minimus* varieties should hereafter be called an *aconitus* variety.

SUMMARY

1. A brief review of the literature on the Philippine *A. funestus* group and rulings on the nomenclature are given.

2. Morphologic study of a series of adult mosquitoes of this group and the larval skins from which they were bred out is presented and discussed.

3. A consideration of the principal characters of the local mosquitoes and those described from Ceylon, Assam, Java, and Malaya shows that there exists a variety of *aconitus* (*filipinæ* var. nov.) in the Philippines which has heretofore been classified as varieties of *A. minimus* Theobald. The opinion is also expressed that the local *minimus* is identical with *A. funestus* (Giles, 1900) emended by Strickland, 1924.

[28] Ind. Journ. Med. Res. 12 (1924) 23–29.

ILLUSTRATIONS

[Microphotographs for figs. 1 and 2 by the Philippine Health Service; for figs. 3 and 4, by the Bureau of Science.]

PLATE 1

FIG. 1. Larval skin of *Anopheles aconitus* var. *filipinæ* showing the "chitinous islets."

2. Larval skin of the Philippine *Anopheles funestus* without the "chitinous islets."

3. "Occipito-clypeal pattern" of *Anopheles aconitus* showing an O-shaped pigmented area.

4. "Occipito-clypeal pattern" of *Anopheles funestus* showing a U-shaped pigmented area.

FURTHER EXPERIMENTS CONCERNING IMMUNOLOGIC RECIPROCITY BETWEEN YAWS AND SYPHILIS

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Additional experimental evidence showing that yaws infection immunizes Philippine monkeys against cutaneous inoculation with syphilis[1] is given in this paper.

Eleven Philippine monkeys that had gone through yaws infection and were proven to be immune to yaws were inoculated with syphilis by intradermal injection on the scrotum. Two normal control animals were included in the test for immunity to syphilis. The shortest interval of time between the first inoculation with yaws and the test for immunity to syphilis was twelve months, the longest twenty-one months. Following the inoculation with syphilis the places of inoculation were inspected regularly for a period of five months. At various intervals of time the inguinal lymph glands corresponding to the point of inoculation with syphilis on the scrotum were removed aseptically and transplanted to the testicles of normal rabbits. The rabbits were inspected weekly for a period of five months and the results were noted. The details are evident from Table 1.

None of the yaws-immune monkeys developed lesions at the places of inoculations with syphilis and none of them harbored viable treponema luis in the lymph glands corresponding to the places of inoculations with syphilis. All normal control monkeys developed typical syphilitic lesions and harbored viable treponema luis in the lymph glands corresponding to the places of inoculation with syphilis.

CONCLUSION

The conclusion drawn from previous experiments[2] that immunity to yaws gained by yaws infection protects Philippine monkeys against cutaneous inoculation with syphilis is hereby confirmed.

[1] Philip. Journ. Sci. 40 (1929) 91.   [2] Loc. cit.

TABLE 1.—*Showing the results of inoculation with syphilis performed on monkeys that were successfully inoculated with yaws twelve months or more before and were proven to be immune to yaws.*

[+, typical lesion; ±, immune reaction; —, no lesion; D, died; 0, not done.]

Designation of monkey.	Inoculation with yaws.		Inoculation test for yaws immunity.[a]		Intradermal inoculation with syphilis.		Date of lesion.		Transplants of lymph glands to rabbits.			
	Date.	Result.	Date.	Result.	Date.	Result.	Appeared.	Healed.	Date.	Result.	Lived.	Died.
E-41	[b] II- 1-28	+	II-27-29	—	VI-22-29	—	—	—	IX-11-29	—	One	IX-14-29, one.
W-55	II-29-28	+	II-27-29	—	VI-22-29	D			0			
J-1	VIII-17-28	+	II-27-29	—	VI-22-29	—	—	—	IX-26-29	—	One	XII-9-29, one.
K-9	VI-26-28 VII-19-28	+ +	II-27-29	—	VI-22-29	—	—	—	IX-26-29	—	One	XII-9-29, one.
W-51	II-27-28	+	II-27-29	—	VI-22-29	—	—	—	IX-26-29	—	Two	
T-15	IX-17-27	+	II-21-29	—	VI-22-29	—	—	—	X- 2-29	—	Two	
W-8	X-25-27	+	II-21-29	—	VI-22-29	D			0			
W-6	X-21-27	+	II-21-29	—	VI-22-29	—	—	—	X- 7-29	—	Two	
W-43	II- 6-28	+	II-21-29	—	VI-22-29	—	—	—	X- 2-29	—	One	XII-3-29, one.
O-1	VI-21-28	+	II-27-29	—	VI-22-29	±	VII-5-29	VII-10-29	X- 4-29	—	Two	
W-16	XII-12-27	+	II-21-29	—	VI-22-29	—	—	—		—	Two	
SyG-22 Control	0		0		VI-22-29	+	VII-5-29	VIII-17-29	X- 4-29	+	Two	
SyG-23 Control	0		0		VI-22-29	+	VII-5-29	VIII-17-29	IX-11-29	+	One	IX-29-29, one.

[a] All normal control monkeys used in the tests for immunity to yaws showed typical yaws lesions containing treponemas.
[b] These letters and figures indicate month, day, and year; thus, II-1-28 means February 1, 1928.

THE XYLOCOPID OR CARPENTER BEES OF THE PHILIPPINE ISLANDS

By T. D. A. COCKERELL

Of the University of Colorado, Boulder

In tropical countries even the most unobservant cannot fail to notice the large carpenter bees, nesting in wood, and often to be seen about houses. In the Philippine Islands, as in other parts of the Oriental Region and throughout tropical Africa, two genera may be found. One, *Mesotrichia* Westwood, has the hind part of the thorax flattened, the scutellum having an abrupt rim, while this posterior thoracic truncation faces a similar basal truncation of the abdomen. The basal segment of the abdomen in most (but not all) species contains a pouch, which opens on the anterior face, and in this pouch will be found mites of the genus *Paragreenia.* In the other genus, *Xylocopa,* the thorax is rounded as in other bees, and the first abdominal segment also lacks a sharp or angular rim above its basal declivity.

The Philippine Xylocopidæ are fairly numerous, and are on the whole very closely allied to species of the nearest parts of Asia. There is evidently a tendency to develop insular species or races, and it is probable that many more of these will be discovered on the islands which have not yet been explored for bees. In the present paper *Mesotrichia cuernosensis* is recorded from Cebu, being the first bee to be reported from that island. Also at Uling, Cebu, September, 1925, A. Duyag, entomological collector of the Bureau of Science, took *Apis binghami* Cockerell.

There is a curious parallelism between the modifications of the Philippine xylocopids and those of Africa. Thus we may say that *M. trifasciata,* with its gray-haired head, parallels the African *M. senior* (Vachal). The group of *M. philippinensis,* the females with yellow hair on the hind part of the thorax and the base of the abdomen, parallels the African group of *M. caffra* (Linnæus) and *M. diversa* (Klug). The red-haired *M. cuernosensis* may be compared with the African group of *M. flavorufa* (DeGeer) and *M. mixta* (Radoszkowski).

In 1917 a paper on the carpenter bees was published in the Philippine Journal of Science. It is now quite out of date, and it is worth while to present a revision. In another twelve years, perhaps, another revision may be required, if the present one creates enough interest to promote collecting all over the Archipelago. These bees are so distinctive, and so easily collected, and it may now be hoped so easily identified, that any amateur can add to our knowledge, if situated in a favorable locality. The natural history of the commonest forms still invites study. Their nesting habits, parasites, and natural enemies remain largely unknown, and in many cases we do not know more than one sex, or are not certain about the association of those we know.

Miss Norma LeVeque, of the University of Colorado, is preparing a revision of the *Paragreenia* mites, found in the abdominal pouches of *Mesotrichia.*

Genus XYLOCOPA Latreille

Subgenus NYCTOMELITTA Cockerell

a^1. Large nocturnal bees, with very large ocelli; thorax above covered with dull red or brownish red hair; apical part of abdomen covered with red hair .... *X. tranquebarica* (Fabricius).

Xylocopa tranquebarica is an Indian species, said to occur in the Philippines but its occurrence there needs confirmation. A closely allied species, *X. grandiceps* (Cameron), occurs from Singapore to Siam; it has much less red hair on the apical part of the abdomen.

Subgenus XYLOCOPA Latreille

a^2. Diurnal bees, the ocelli not specially enlarged.

b^1. Smaller bees, the anterior wing about 16 or, sometimes, as much as 18 millimeters long; face of male narrow, the area below antennæ about as broad as long; sexes differently colored, the male with a good deal of olive-brown hair; the female black with the abdomen dark green.. *X. fuliginata* Pérez.

The type of *X. fuliginata* was from Mindanao; in 1927 Francisco Rivera, one of Mr. McGregor's assistants, collected it at Mati and Mount Mayo, Davao, Mindanao. It is common in Luzon, and is known from Basilan. In Samar is a distinct race, *X. fuliginata indecisa* Cockerell and LeVeque, the female with wings very dark with brilliant purple-blue colors; posterior part of mesothorax more sparsely punctured; abdomen distinctly green, but the color obscure and only well seen on comparison with black.

Xylocopa nigrocærulea Smith, described from Celebes, was recorded from Palawan, Mindoro, and Mindanao by Gribodo. It is practically certain that *X. fuliginata* was mistaken for it; but should it be found it will be known by the flagellum of the female antennæ being testaceous beneath except at the base (black or faintly reddish beneath in the female of *X. fuliginata*); the tarsi rufescent apically (black in *X. fuliginata*); and the wings with coppery iridescence (rosy purple in *X. fuliginata*). Smith described only the female of *X. nigrocærulea.*

The Philippine record of *X. sonorina* Smith, a species of the Sunda Islands, is still more doubtful. The female will be known from that of *X. fuliginata* by the red (instead of black) hair of the anterior tarsi. *Xylocopa mazarredoi* Dusmet, from Palawan, is of this alliance. It is based on a female with the anterior wings 16 millimeters long. I have not seen it, but it must be distinct, by the little darkened wings (strongly darkened in the female of *X. fuliginata*), the partly gray hair, and the red hair on the tarsi. These characters are suggestive of the European *X. cantabrita* Lepeletier, but there is probably no real affinity.

*b*². Larger bees, the anterior wing over 20 millimeters long; face of male broad, the area below antennæ much broader than long. There are several different forms, separable thus:

*c*¹. Wings brilliant rosy purple, with the apical field peacock green; anterior wing of female 28 millimeters long; abdomen black, without green tints.. *X. dissimilis* Lepeletier.

Xylocopa dissimilis, a Chinese species, has been reported from the Philippines, but probably has been confused with *X. fallax.* Pérez reports a supposed variety of *X. dissimilis* from Palawan, the wings (female) with feeble blue-green and violet reflections, a little coppery in the apical region.

*c*². Wings otherwise colored, not so brilliant; anterior wing, 21 to 26 millimeters.

*d*¹. Abdomen distinctly greenish; male with larger part of clypeus pale; anterior wing of female, 23 millimeters; of male, 26.
X. fallax Maidl.

Xylocopa fallax was described from two females and a male collected in the Philippines, the island not stated. It was compared with *X. auripennis* Lepeletier, with which it agrees in the male genitalia; *X. fallax* has the abdomen more densely punctured than *auripennis,* which occurs in Borneo and elsewhere.

Its affinities being with a Bornean species, we may suspect that it came from Palawan.

*d*². Abdomen black.

*e*¹. Male with only a small part of clypeus (band at upper end) light, but supraclypeal area and broad lateral face marks dull pale yellow, and a yellow mark at each side of anterior ocellus; wings very dark, shining green, with some violaceous. Palawan .... *X. mimetica* Cockerell.

*e*². Male with lower half or only broad lower margin of clypeus black; anterior wing of female, 21 to 24.5 millimeters long, of male, 22 to 23. Luzon............ *X. mcgregori* Cockerell.

Xylocopa mcgregori, common in Luzon, has been regarded as a race of *X. fallax*. It is very much like *X. pictipennis* Smith, from Java, but *pictipennis* has the third antennal joint conspicuously longer, and the punctures on the clypeus larger and not so dense. The wings are dark, the basal part variably green, the apical field rosy purplish. They are similarly colored in *pictipennis*.

*e*³. Male with clypeus, except lower margin, semicircular supraclypeal area, lateral face marks, and the usual marks at sides of anterior ocellus, cream-color; separated from *X. mcgregori* by the almost entirely pale clypeus, large patch of light hair on pleura, and darker hair of mesonotum anteriorly; anterior wing, 21 millimeters long. Ten miles east of Olongapo, Luzon............ *X. thompsoni* Cockerell.

The type of *X. thompsoni* is in the museum of the California Academy of Sciences, San Francisco. It was collected by J. C. Thompson in May, 1907.

Genus MESOTRICHIA Westwood

The type of this genus is an African species, not closely related to those of the Orient; but there is no sufficient reason for recognizing three or four genera as proposed by Ashmead.

Subgenus PLATYNOPODA Westwood

Very large bees, anterior wing over 25 millimeters long; thorax dark above; first abdominal segment without light hair; scutellum not hairy. There are two species, separable thus:

Scape of antennæ not distinctly enlarged at end (a species of the Indian region, probably not occurring in the Philippines). *M. tenuiscapa* (Westwood).

Scape enlarged at end............ *M. latipes* (Drury).

Mesotrichia latipes has two races in the Philippines, which differ as follows:

Wings brilliant green, brassy apically, purple at extreme base. Negros and Panay .... *M. latipes* (Drury).
Wings very dark, splendid deep purple, the basal half with some bluish green tints. Palawan........ *M. latipes basiloptera* Cockerell.

The anterior legs of the male in this species are greatly modified, the basitarsi broad, flattened, shining, cream color, with very long dark brown hair behind. The eyes of the male are very large, and nearly meet at the top of the head.

The large black female of *M. bombiformis*, if confused with *M. latipes,* is easily distinguished by the hairy scutellum. *Mesotrichia latipes* was recently taken at Lake Dako, Negros, by A. Duyag.

Subgenus KOPTORTHOSOMA Gribodo

This group includes the more ordinary species of the genus, the type of *Mesotrichia* being aberrant. The males are so different in appearance from the females that it is difficult to associate the sexes, and until observations are made of the living bees at their nests, there will remain a good deal of uncertainty. The males appear yellowish or greenish from a covering of hair, and are more alike than the females of the same species. Some species (*M. major, M. vachali, M. clavicrus, M. euchlora,* and *M. subvolatilis*) were originally described from males. *Mesotrichia clavicrus* Maidl, said to occur in Luzon and Ceylon, I have never seen. The male is said to be near *M. volatilis* Smith; the hind femora are extremely broad. In the Philippine fauna it should be readily recognizable by the reddish yellow clypeus. The following table separates the males known to me:

Males of the subgenus Koptorthosoma Gribodo.

1. Hair on apical part of abdomen entirely ferruginous red; hair of thorax above dense and yellow, of hind tibiæ yellow, with a red stripe posteriorly, of hind tarsi with light yellowish red; length, about 21 millimeters; anterior wing, 19; the female is unknown. Mindanao. *M. subvolatilis* Cockerell.
   End of abdomen not thus red haired, though the hair may be partly red or reddish yellow; colors in general usually duller or greener.... 2.
2. Very large robust bee, the anterior wing about 23 millimeters long. Luzon .... *M. major* (Maidl), which is the male of *M. bombiformis* (Smith).
   Smaller; anterior wing, 20 millimeters or less.. 3.

3. Abdomen thinly hairy, appearing black seen from behind; clypeus very thinly hairy, the surface exposed................ *M. cuernosensis* Cockerell.
   Abdomen more hairy, appearing yellowish or greenish........................ 4.
4. Hair of thorax as well as abdomen green; rather large and robust species .... *M. euchlora* (Pérez).

   This has been thought to be the male of *M. philippinensis*, but I now incline to refer it to *M. ghilianii.* Both *euchlora* and *ghilianii* occur in Mindanao.

   Hair of thorax not distinctly green, but ocherous or yellow.................... 5.
5. Clypeus with dense hair, concealing surface.. 6.
   Clypeus with thin hair, not concealing surface... 7.
6. Larger and more robust, 7 millimeters between tegulæ; colors brighter; marginal cell fuliginous.. *M. confusa* (Pérez).

   Mesotrichia confusa is widely distributed in the Orient, but its occurrence in the Philippines must be considered doubtful; *M. vachali* (Pérez), described from Palawan, is said to be very near to *M. confusa;* the yellow hair of thorax is tinted with red; on abdomen the tint is olivaceous, becoming dusky from the admixture of black hairs. Pérez suggests that it is the male of *M. amauroptera*, the latter name having priority of place.

   Smaller and less robust, hardly 6 millimeters between tegulæ; colors duller; marginal cell subhyaline........................ *M. bakeriana* Cockerell.
7. Clypeus more hairy; supraclypeal mark very small; longitudinal light bar on clypeus not meeting yellow of lower margin; abdomen strongly greenish. Samar .... *M. canaria* Cockerell and LeVeque.

   This is the *euchlora*-like form referred to *M. philippinensis samarensis*, but as was suggested as a possibility at the time, it appears to belong to *M. canaria.* It is extremely close to *M. euchlora*, but the hair of the thorax is evidently more yellow. If this is *canaria*, it seems reasonable to refer *euchlora* to the closely allied *M. ghilianii.*

   Clypeus less hairy; supraclypeal mark large; longitudinal pale band on clypeus uniting with yellow of lower margin; abdomen rather dark (the hair not very dense), not greenish.
   M. philippinensis chlorina Cockerell.

   The male of *M. philippinensis samarensis*, referred to as having the hair of thorax anteriorly suffused with reddish, and the lateral portions of the apical yellow band on clypeus claviform, is little different from *chlorina*, and will run to the same place in the table. This is different from the greenish males, now considered to be *M. canaria.*

In December, 1924, males of *M. major* (*bombiformis*) were taken by A. Duyag at Tapolao, Zambales Mountains, Luzon.

Groups of females of the subgenus Koptorthosoma Gribodo.

The females may be readily sorted into groups as follows:

Thorax covered with bright yellow hair above.... Group of *M. confusa.*
Thorax with red hair (and some black) above; abdomen black.
Group of *M. cuernosensis.*

Thorax with yellow hair in front and behind, but middle or disc black. Group of *M. ghilianii.*

Thorax with a yellow or reddish band or patches posteriorly, but not in front .... Group of *M. philippinensis.*

Thorax above all black; second cubital cell open at lower basal end. Group of *M. dapitanensis.*

Thorax above all black; second cubital cell complete. Group of *M. bombiformis.*

Thorax above black, but differing from all the above by having the abdomen red except at base.......... Group of *M. tricolor.*

Group of Mesotrichia confusa.

Mesotrichia confusa (Pérez) has been reported, but I have never seen it from the Philippines.

Group of Mesotrichia cuernosensis.

Mesotrichia cuernosensis Cockerell is a fine large species, easily recognized by the red hair (mixed with black) on the thorax above and the rosy tint of the wings. It was described from Negros, and has more recently been collected on that island by A. Duyag (Lake Dako, 1925). It is common on Panay. In September, 1925, Duyag took it at Naga and Uling, Cebu. This is the first record of a bee from Cebu.

Although *M. cuernosensis* appears to have no close relative in the Philippines there is a very similar species (superficially appearing practically the same), *M. tambelanensis* Cockerell, on Big Tambelan Island, in the southern part of the China Sea.

Group of Mesotrichia ghilianii.

These large and handsome forms are sufficiently diversified to have given occasion for seven specific names, and it is certain that other segregates will be discovered in still unexplored localities. The following key will facilitate recognition:

Key to the females of the Mesotrichia ghilianii group.

1. Head densely gray-haired; otherwise very like *M. nigroplagiata* (Ritsema), from the Aru Islands; first abdominal segment densely yellow-haired; length, 21 to 22 millimeters. Mindanao. *M. trifasciata* (Gribodo).

   Head not thus gray-haired .... 2.
2. First abdominal segment with conspicuous yellow hair.......... 3.

   First abdominal segment appearing black, but the lens may show a little yellow hair .... 4.
3. Yellow hair of first segment lacking posteriorly; wings beautiful green, practically without purple; yellow hair of thorax more extensive than in *M. ghilianii,* with a conspicuous line above tegulæ, so that the disc

of mesothorax has a very large subquadrate black patch, broader than long, its outline more or less trilobed posteriorly; extreme base of wing with a tuft of yellow hair (a black tuft in *ghilianii*); abdomen much less densely and roughly sculptured than in *ghilianii*, and ocelli much smaller. Samar........ *M. canaria* Cockerell and LeVeque.

Yellow hair covering first segment dorsally.. 4.

4. Larger, length, about 24 millimeters; hair of head practically all black, but a few yellow hairs may be seen on cheeks. Mindanao and Samar. *M. ghilianii* (Gribodo).

Smaller, length, about 21 millimeters; with lemon yellow hair mixed with black on face. Mindanao .... *M. blüthgeni* (Dusmet).

Mesotrichia canaria is also larger than *blüthgeni*, about 23 millimeters long, with anterior wing 21; wing of *blüthgeni*, 20.

5. Abdomen little hairy, the surface exposed; hair of head above black, but thin inconspicuous yellow hair on cheeks and sides of occiput; differs from *M. canaria* by yellow hair on mesopleura being more reduced, forming a triangular patch on upper part; wings with strong blue-green and purple tints; length, about 20 to 22 millimeters; anterior wing, 20 to 21. Lucban, Tayabas Province, Luzon. *M. lucbanensis* Cockerell.

Abdomen strongly hairy, the hair more or less concealing the surface; species closely allied to *X. nobilis* Smith, from Celebes........................ 6.

6. Head with black hair; anterior yellow band broader; wings dark brown, with very feeble greenish and bronze reflections. Mindanao. *M. adusta* (Pérez).

Head with hair whitish behind, yellowish on vertex; anterior band of thorax narrower; clypeus keeled. Mindanao.... *M. occipitalis* (Pérez).

Pérez states that the second cubital cell is smaller in *M. adusta* and *occipitalis* than in *ghilianii*.

In the above tables *M. trifasciata, blüthgeni, adusta,* and *occipitalis* were placed from the descriptions. It will be noticed that they all come from Mindanao, which seems to have an extraordinary concentration of species. Hedicke (1926) recorded *M. blüthgeni* from Puerto Bangco (probably Port Banga), Mindanao, and considered it valid. A specimen collected by F. Rivera at Mati, Davao, Mindanao, March, 1927, is evidently *M. blüthgeni*. It is certainly very much like *M. ghilianii*, but evidently smaller, with an admixture of yellow hair in the region about the antennæ. The wings do not differ in color from those of *M. canaria*, and the little tuft at the base of the anterior wings is yellow as in *M. canaria*, not black as in *M. ghilianii*. The yellow hair on the first segment covers the surface as in *M. ghilianii*. The clypeal keel is quite strong. Thus the species resembles *M. ghilianii* in some respects, and *M. canaria* in others, but is definitely separable from both.

Another female, obtained by Rivera in the same locality, but in April, appears at first sight to be exactly the same as *M.*

blüthgeni. At first I could hardly persuade myself that it was more than a variation, but it is a distinct species, differing thus: Head with gray hair, conspicuous on cheeks, strongly mixed with black on vertex and face; clypeus dull and more closely punctured (in *blüthgeni* with smooth spaces between the very large punctures in the central portion); clypeal keel very slender, hardly shining; hair below clypeal margin red (dark in *blüthgeni*); and admixture of yellow hairs on occiput; abdomen in middle of second segment much less hairy and less closely punctured; wings with the same appearance and color, but second cubital cell short and open at base. The first abdominal segment is covered with yellow hair. This is *M. trifasciata* (Gribodo), to which it runs in the key.

Group of Mesotrichia philippinensis.

1. Very small; length, 15 millimeters; breadth, 6.5; like *M. philippinensis*, but much smaller, with hind margin of thorax with yellow hair band; pleura black-haired. Luzon .... *M. bilineata* (Friese).

   This was described by Friese in 1914 from one specimen. No other has been found, and I have not seen it. So far as the description shows, the wings do not differ from those of *M. philippinensis*.

   Larger, at least 18 millimeters long.............................. 2.
2. Wings dark rosy purple, at most with a little greenish apically; posterior yellow band reduced to lateral patches (which is not true of *bilineata*) .... 3.

   Wings at least largely greenish, or golden green.............................. 4.
3. Very large; anterior wing, about 24 millimeters long; yellow hair at sides of thorax posteriorly, below base of wings, and on first abdominal segment. Luzon.............................. *M. philippinensis* (Smith).

   Very small; about 18 millimeters long, anterior wing, 16.7 millimeters long; reddish yellow hair well developed at sides of scutellum, yellow patch beneath base of wings very small. Malinao, Tayabas, Luzon (*Baker 3661*).............................. *M. philippinensis tayabanica* var. nov.

   For the present I regard *tayabanica* as a variety of *philippinensis*, but it may prove to be a distinct species. In the British Museum I saw three specimens marked "sent as *philippinensis*," and noted that they were much smaller. Probably they are *tayabanica*, but I cannot now be sure.
4. Hair of thorax posteriorly yellow. The common form in Luzon; recently collected specimens are from Anuling, Zambales, December 19, 1924, *A. Duyag;* and Antipolo, Rizal, January, 1925, *A. Duyag*.
   M. chlorina (Cockerell).

   I have always considered *chlorina* a race of *philippinensis*, but it is probably a distinct species. It is, however, variable as set forth in Philippine Journal of Science **16** (1920) 206.

   Hair of thorax posteriorly reddish; less white hair on face than in *chlorina*, the general effect in lateral view being black, with hardly any white. Samar .... *M. samarensis* Cockerell and LeVeque.

Described as *M. philippinensis samarensis,* but if *chlorina* is considered a species, it must either rank as a subspecies of that, or as a distinct species.

Dusmet in 1924 described two species from females of the *M. chlorina* group, namely:

Mesotrichia maesoi (Dusmet). Three from Tayabas, one from Dolores, and one without special locality. Length 22 to 23 millimeters; wing 17 to 18 millimeters; specimens in bad condition, but scutellum has lemon yellow hair, and there is a very little on pronotum; wings with golden reflections, and weaker violaceous color basally.

Mesotrichia ceballosi (Dusmet). Two from Manila, and Imugan. Length 20 millimeters; wing 17 millimeters; scutellum with lemon yellow hair; wings with magnificent golden yellow reflections, with a little violaceous.

The type of *M. chlorina* has the anterior wing a little over 17 millimeters; that of *samarensis,* 18.5, though another specimen is larger, with wing 22. The larger *samarensis,* perhaps to be separated, has the reddish hair on the scutellum reduced to small lateral patches. Some time ago I concluded that *maesoi* could not be separated from *chlorina,* and I remain uncertain about *ceballosi.* Dusmet had seven specimens of the *chlorina* group, which he regarded as pertaining to two species, but none at all of the common *chlorina,* so far as appears. Hedicke has recorded *chlorina* from Lamao and Imugan.

Group of Mesotrichia dapitanensis.

Mesotrichia dapitanensis Cockerell, from Dapitan, Mindanao, is a small black species, about 16 millimeters long; anterior wing, 14. The wings are strongly brownish, darker in apical field, reddened in marginal cell, with a greenish golden iridescence, dilute rosy apically. It most resembles *M. bakeriana,* but is much smaller, with the ocelli farther apart, the wings paler and redder, and the process on hind tibiæ different. It was obtained by C. F. Baker.

Group of Mesotrichia bombiformis.

1. With a band of grayish white hair behind eyes; wings very dark, apical part green. Palawan .... *M. amauroptera* (Pérez).
   With only black hair behind eyes........ 2.
2. Cheeks, behind eyes, closely punctured; wings with golden-green luster. Luzon .... *M. bakeriana* Cockerell.
   Cheeks behind eyes shining and very sparsely punctured. *M. bombiformis* (Smith).

The large robust *M. bombiformis,* with anterior wings fully 25 millimeters long, is common in Luzon. Recently collected females are from Anuling, Zambales (*A. Duyag*); Irisan, Benguet (*A. Duyag*); and Antipolo, Rizal (*M. Ramos*). The scutellum is hairy, at least at the sides. The other species are much smaller.

Group of Mesotrichia tricolor.

Mesotrichia tricolor (Ritsema), a large species, 27 millimeters long, is described from the Sula Islands, and probably does not occur in the Philippine Islands.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), VII[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

TWO PLATES

As before, the present report is based entirely on important collections of crane flies received from Mr. Richard C. McGregor. The most important series include material taken in Cagayan Province, northeastern Luzon, in April and May, 1929, by Mr. F. Rivera and further collections made at and above Ube, Laguna Province, at the foot of Mount Banahao, by Messrs. McGregor, Duyag, and Rivera. Under the capable and intelligent methods of collecting employed, our knowledge of the tipulid fauna of Luzon is developing very rapidly. My thanks are extended to the collectors for the privilege of retaining the types in my collection.

TIPULINÆ

TIPULODINA TABUANENSIS sp. nov. Plate 1, fig. 1.

Mesonotal præscutum obscure yellow with four brown stripes that are narrowly margined with brownish black; antennæ bicolorous; basitarsi black, the central third white; wings whitish subhyaline, with a restricted dark pattern; no dark area in cell M.

Female.—Length, about 22 millimeters; wing, 15.

Frontal prolongation of head yellow, with a brown lateral stripe; palpi light brown, the distal end of the terminal segment extensively orange. Antennæ bicolorous; basal segment yellow, tipped with brown; second segment brown; flagellar segments darkened at bases, paling to dirty white at tips; outermost segments more uniformly darkened. Frons light yellow, the vertex reddish brown, the median and lateral portions of the darkened areas more blackish; genæ and ventral surface yellow.

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

Pronotum yellow, dark brown medially. Mesonotal præscutum obscure yellow, with four brown stripes that are narrowly margined with brownish black, the intermediate pair separated only by this darkened margin; scutal lobes obscure yellow, each with two brown areas; scutellum obscure yellow, with a brown median line; postnotum gray, the posterior margin with two brown areas. Pleura light yellow, sparsely variegated with black, including a small area immediately above the fore coxa; a small spot dorsad of the midcoxa and a large arcuate area on the pleurotergite. Halteres black, the base of the stem and the extreme base of knobs pale. Legs with the coxæ yellow, the posterior margin of the hind coxæ darkened; trochanters yellow, infuscated apically; femora obscure yellow, the tips of the fore femora very broadly blackened, with a conspicuous white subterminal ring; middle and hind femora more narrowly blackened at tips; fore and middle tibiæ black, with a narrow white ring beyond midlength; posterior tibiæ black with a similar white ring and an additional subbasal slightly narrower white ring; basitarsi black, the central third snowy white; second tarsal segment white, the base narrowly blackened; segments three and four white; terminal segment infuscated. Wings (Plate 1, fig. 1) whitish subhyaline, with a restricted brown pattern; stigma brown, connected with a narrow seam on anterior cord; a narrow dark cloud on m-cu at junction with Cu; wing apex narrowly darkened, most extensive in the radial field, in cell R_3 this darkening inclosing a gray triangle; no darkening in cell M. Venation: R_{1+2} short, less than R_{2+3}, R_3 very long; m-cu about two-thirds as long as the distal section of Cu_1.

Abdominal tergites one and two yellowish brown, the latter passing into brown at margin; succeeding tergites dark brown, segments three to six narrowly margined with yellow; outer segments more uniformly infuscated; sternites more uniformly pale.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, female.

This species and the others of this genus now known from the Philippines may be separated by means of the following key:

1. Wings hyaline, iridescent; no dark mark at near midlength of cell M adjoining vein Cu_1 .... 2.
   Wings tinted with yellow; a dark spot in cell M at near midlength of vein Cu_1 .... 3.
2. Legs with the basitarsi entirely black.......... *T. luzonica* Alexander.
   Legs with the basitarsi black, the central third snowy white.
   T. tabuanensis sp. nov.

3. Dark spot in cell M very extensive, extending across both cells R and M; basitarsi black, with a white ring at near midlength.
T. cagayanensis sp. nov.
Dark spot in cell M reduced, confined to the cell; white leg pattern very much reduced, the tarsi entirely black or with a nearly obsolete pale ring only .... *T. succinipennis* sp. nov.

TIPULODINA SUCCINIPENNIS sp. nov. Plate 1, fig. 2.

General coloration yellow, the præscutum with four brown stripes; pleura unmarked; legs black, the usual white rings nearly lacking, especially in the male; wings amber yellow, with a dark pattern that includes a small area at near midlength of cell M; male hypopygium small, the appendages inconspicuous; eighth sternite unarmed.

Male.—Length, about 20 millimeters; wing, 18.

Female.—Length, about 26 millimeters; wing, 20.

Frontal prolongation of head ocherous, narrowly darkened on sides; nasus elongate; palpi obscure yellow, the third and basal portion of the fourth segment darkened. Antennæ (male) of moderate length, if bent backward extending about to the root of the haltere; scape obscure yellow; first flagellar segment light brown; remainder of flagellum black, the extreme bases of the proximal segments darkened; flagellar segments elongate, subcylindrical, the basal enlargement small, the verticils shorter than the segments. Anterior part of head ocherous, the posterior portion more infuscated, with a conspicuous dark brown median stripe on the posterior vertex, extending cephalad to the small vertical tubercle.

Pronotum yellow, narrowly dark brown medially. Mesonotal præscutum yellow, with four conspicuous brown stripes that are narrowly bordered by darker; a circular dusky area on lateral margin of præscutum behind the pseudosutural foveæ; scutum golden yellow, the lobes almost covered by extensive brown areas; scutellum yellow, darker behind, with a median brown line; postnotal mediotergite olive brown with a capillary dark median line. Pleura yellow. Halteres dark brown, the base of the stem restrictedly brightened. Legs with the coxæ and trochanters yellow; femora brownish yellow, brighter at base, the tips narrowly blackened, on the fore and middle femora (male) preceded by a vague brighter yellow subterminal ring that is subequal to the darkened apex; tibiæ and tarsi black, in male with indications of a vague pale subbasal ring on tibia; in the female there are very narrow and only vaguely evident obscure whitish rings, one on the fore and middle tibiæ, two on the posterior

tibiæ, and one on the basitarsus beyond midlength. Wings (Plate 1, fig. 2) tinted with light amber yellow, with a dark pattern as follows: Cell Sc; a continuous crossband at cord, extending from the stigma completely across the wing; m and veins M_1 and M_2; outer ends of cells R_2 and R_3 solidly darkened or with a pale center in cell R_3; a small dark cloud in cell M at near midlength, this a little more extensive in the female. Venation: Forks of medial cells shallow; cell 2d A of moderate width.

Abdominal tergites obscure yellow, patterned with brownish black, this including subcaudal and sublateral lines on the segments, with an interrupted dorsomedian line, especially evident in the female; basal ring of tergites brighter, more ocherous, especially in female; lateral margins of tergites pale; subterminal segments blackened; sternites yellowish; hypopygium yellow. Male hypopygium small and inconspicuous. Ninth tergite with the caudal margin subtransverse to feebly concave, the low lateral lobes blackened and setiferous, the median area glabrous. Spinous hooks of the basistyle small, blackened. Eighth sternite unarmed.

LUZON, Laguna Province, Majayjay, Mount Banahao (*R. C. McGregor*); holotype, male, May 10, 1929; allotype, female, May 11, 1929.

Tipulodina succinipennis is very distinct from *T. tinctipes* (Edwards) in the coloration and in the structure of the male hypopygium. *Tipulodina joana* (Alexander) of Japan likewise has the white pattern of the legs greatly reduced, at the same time lacking the dark spot in cell M of the wings.

TIPULODINA CAGAYANENSIS sp. nov. Plate 1, fig. 3.

General coloration dark brown; antennal flagellum black, the incisures narrowly pale; fore and middle femora with a subterminal white ring; fore and middle tibiæ with white subterminal ring; posterior tibiæ with two white rings; all basitarsi black, with a broad white medial ring; wings pale yellow with a heavy brown pattern, including a large area that completely crosses cells R and M at near midlength.

Female.—Length, about 27 millimeters; wing, 18.

Frontal prolongation of head light ocherous, the sides with a narrow dark brown lateral line; nasus conspicuous; palpi with the first segment dark brown, the succeeding two segments brownish yellow, the terminal segment dark on basal half, the

tip paling to yellow. Antennæ with the basal segment black, narrowly pale at base; flagellum black, the incisures very narrowly pale. Center of vertex dark grayish brown, the orbits irregularly ocherous; an oblique velvety-black line immediately behind each antenna, these almost meeting on the midline.

Mesonotal præscutum with the ocherous ground color restricted to the humeral and lateral portions and somewhat more darkened interspaces; four dark stripes, the intermediate pair separated by a more velvety-black line; a humeral gray triangle; a dusky spot on lateral margin of præscutum before the suture, extended ventrad across the dorsopleural region; scutal lobes chiefly dark brown; scutellum brownish yellow, with a dusky median line; postnotum similarly brownish yellow, the cephalic and especially the caudal portion bordered by dark brown. Pleura chiefly pale, with a whitish pollen, the ventral sternopleurite and pleurotergite variegated with dark brown. Halteres dark brown, the base of the stem narrowly pale. Legs with the coxæ pale, pollinose, the posterior face of the hind coxæ with a dark spot; trochanters chiefly dark brown; fore and middle femora black, the bases obscure yellow, each with a broad white subterminal ring; tibiæ black, with a broad white subterminal ring, this a little narrower than the apex beyond; basitarsi black, with a broad white medial ring, this a little narrower than the black basal portion; second tarsal segment white, the base narrowly blackened; segments three and four entirely white; segment five black; hind legs without the subterminal white ring on femora; tibiæ with two white rings; tarsi as in other legs. Wings (Plate 1, fig. 3) broad, with a pale yellow tint, the dark pattern heavy; cell Sc black; a heavy dark seaming completely crosses the wing at the cord; other broad seams in distal half of outer radial cells, outer end of cell 1st M_2 and all medial veins, as well as the apical margin of the wing; a very extensive brown cloud completely traverses cells R and M; veins black. Venation: Forks of medial cells shallow; cell 2d A of moderate width.

Abdominal tergites dark brown, the narrow basal ring variegated with obscure yellow laterally, caudal margins of segments narrowly ringed with pale; sternites obscure yellow.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, female.

The diagnostic features above indicated readily separate this species from the numerous allied forms. The darkened area in

cells R and M is of unusual extent; in most species it is confined to cell M or is lacking.

DOLICHOPEZA (DOLICHOPEZA) ISOLATA sp. nov. Plate 1, fig. 4.

General coloration brown; halteres and legs chiefly brownish black or black; wings with a faint brown tinge, slightly variegated with darker; R_{1+2} preserved as a long basal spur; medial forks deep; abdominal segments obscure yellow, ringed with brown.

Male.—Length, about 10 millimeters; wing, 10.2; antennæ, about 5.

Frontal prolongation of head dark above, pale beneath; palpi black. Antennæ relatively elongate, totaling about one-half the length of the body; scape and first flagellar segment yellow; remaining segments passing into brown, the basal enlargement darker; verticils shorter than the segments; terminal flagellar segment reduced to a tiny button. Anterior portion of head yellow, the posterior portion extensively darkened.

Pronotum darkened medially. Mesonotal præscutum light brown, without clearly defined stripes centers of scutal lobes conspicuously blackened. Pleura yellow, with a dusky transverse girdle on the anepisternum and sternopleurite; dorsal portion of pleurotergite darkened. Halteres brownish black, the base of the stem yellow. Legs with the coxæ and trochanters yellow, the outer face of the middle coxæ slightly infuscated; femora yellow basally, passing into dark brown; remainder of legs black. Wings (Plate 1, fig. 4) faintly tinged with brown; cells C and Sc darker brown, the former slightly more yellowish; stigma long-oval, dark brown, preceded and followed by small cream-colored obliterative areas; wing apex narrowly darkened; restricted brown seams along the cord and distal section of M, more conspicuous on m-cu. Venation: Rs short, nearly straight, a trifle longer than r-m; basal spur of R_{1+2} preserved; medial forks very deep; m-cu some distance before the fork of M; cell 2d A relatively wide.

Abdominal tergites obscure yellow, the incisures of the tergites darkened, the caudal margins more broadly so than the bases; sternites yellow, the caudal margins narrowly ringed with dusky, the outer segments and hypopygium clear yellow.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*).

The only other species of *Dolichopeza* known to me with a similar venation of the radial field is *D. malagasya* Karsch

(Madagascar). The venation in this latter species has been described and correctly interpreted by Osten Sacken.[2]

NESOPEZA ANNULITARSIS sp. nov. Plate 2, figs. 19–21.

General coloration brown; legs brownish black, the tarsi white with a broad black ring at midlength of the basitarsi; wings dusky, the oval stigma dark brown; male hypopygium with the tergite produced dorsad into a narrow plate that divides into two simple parallel lobes separated by a narrow notch.

Male.—Length, 9 to 10 millimeters; wing, 11.5 to 12.

Frontal prolongation of head yellow; palpi black. Antennæ with the scapal segments obscure yellow, the flagellum black; antennæ relatively short, if bent backward extending to the wing root or slightly beyond; flagellar segments gradually decreasing in length outwardly, segments seven to twelve more nearly equal; terminal segment very small; verticils short, unilaterally arranged. Head brown.

Mesonotum opaque brown, unmarked, in one paratype more reddish brown with narrow darker interspaces. Dorsal pleurites dusky, the ventral sclerites paling to light yellow. Halteres brownish black. Legs with the coxæ and trochanters yellow; femora brownish black, their bases restrictedly pale yellow; tibiæ brownish black, the extreme bases whitened; tarsi white, the basitarsi with a blackened ring in the middle, broadest on forelegs where more than one-half the segment is included, narrowest on the hind legs where the band occupies a little more than one-third the segment; on the middle legs the proximal ends of the basitarsi are more infumed. Wings dusky, the small stigma dark brown, preceded and followed by whitish obliterative areas; veins brownish black to black. Venation: Rs a little shorter than R_{2+3}; forks of medial field deep; cell 2d A very long and narrow.

Abdominal tergites dark brown, narrowly ringed with yellow on basal portions; sternites more extensively yellow, the subterminal segments blackened; hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 19) with the caudal margin of the tergite (Plate 2, fig. 20) produced dorsad into two slender lobes that are separated by a narrow U-shaped notch, the apex of each lobe weakly and unequally bilobed. Inner dististyle as figured (Plate 2, fig. 21). Ninth sternite, *9s*, relatively large, appearing as a sheathing structure, the apex deeply emarginate,

[2] Berliner Ent. Zeitschr. **31** (1887) 238.

the lobes provided with long conspicuous pale setæ. Ædeagus, *a*, very long, slender and sinuous, lying in the concavity of the ninth sternite, directed dorsad and caudad, gradually narrowed to an acute point.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; paratypes, 2 males.

Nesopeza annulitarsis is closest to *N. cinctitarsis* Alexander (Luzon), differing in the structure of the male hypopygium, especially the narrow lobes of the tergite and the longer ædeagus.

NESOPEZA ANGUSTAXILLARIS sp. nov. Plate 1, fig. 5; Plate 2, figs. 22, 23.

Closely allied and similar to *N. cinctitarsis*, differing especially in the small, unmodified male hypopygium.

Male.—Length, 8.5 to 10 millimeters; wing, 9 to 10.

Female.—Length, about 11 to 13 millimeters; wing, 10 to 11.

Frontal prolongation of head testaceous yellow; palpi brown. Antennæ brownish black, the second segment yellow; flagellar segments long-cylindrical, with short inconspicuous verticils; segments gradually decreasing in length outwardly, the terminal segment very small. Head brown, the vertical tubercle and frons light yellow.

Mesonotal præscutum uniform brown; scutal lobes brown, each with two darker-brown areas; scutellum brown, the postnotum darker brown. Pleura pale brown, variegated with darker. Halteres elongate, brownish black. Legs with the coxæ yellowish testaceous; trochanters yellow; femora brown, passing into dark brown outwardly; tibiæ black, the extreme bases whitish; tarsi snowy white, the basitarsi with about the central third to half black, narrowest on the posterior legs; in some specimens the proximal white of the basitarsi is more or less obscured, especially on the middle legs. Wings (Plate 1, fig. 5) with a brownish tinge, the small oval stigma dark brown; a seam along vein Cu; apical margin a little infumed; veins brownish black. Venation: Forks of medial cells deep; cell 2d A very long and narrow.

Abdominal tergites dark brown, the segments more or less variegated with yellow on the basal rings, the color more distinct on the outer segments; sternites more yellow, their bases darkened; seventh segment entirely blackened; hypopygium reddish brown. Male hypopygium (Plate 2, fig. 22) very simple in structure. Ninth tergite (Plate 2, fig. 23) neither extensively developed nor arched as in the allied *cinctitarsis* and *annulitarsis*; caudal margin with a broad chitinized median point

and broader bispinous lateral lobes that are separated from the median lobe by oval incisions; inner arm of lateral lobe a slender spine, the outer arm broader and merging beneath into the chitinized lateral portions of the sclerite. Outer dististyle, *od*, a subcylindrical straight dusky lobe that is provided with long conspicuous setæ. Inner dististyle (Plate 2, fig. 22, *id*) an expanded setiferous blade that is extended into an apical arm, as figured. Eighth sternite, *8s*, extensive, appearing as a sheathing troughlike structure, the caudal margin unarmed.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; allotype, female; paratypes, 15 males and females. Additional paratypes, Mount Dos Cuernos, April, 1929 (*F. Rivera*); 1 male, Mount Crista, April, 1929 (*F. Rivera*); 1 male, Mount Irid, Rizal Province, December, 1926 (*Rivera and Duyag*).

Nesopeza angustaxillaris is very similar to *N. cinctitarsis* Alexander and N. *annulitarsis* sp. nov., likewise from Luzon, differing very notably in the small simple male hypopygium.

CYLINDROTOMINÆ

STIBADOCERA PUMILA sp. nov. Plate 1, fig. 6.

Size small (length of body or wing about 5.5 millimeters); general coloration black; antennæ approximately as long as the body; wings with a faint dusky tinge, the prearcular and costal regions more blackish; cell M_2 open by the atrophy of m, this character possibly not normal for the species.

Male.—Length, about 5.5 millimeters; wing, 5.5; antenna, about 5.5.

Rostrum and palpi small, black. Antennæ approximately as long as the body; first scapal segment brown, the second yellow; flagellum black; flagellar segments cylindrical, with long erect verticils that are arranged more or less evidently in three whorls. Head polished black, impunctate; head broad, the anterior vertex about one-half wider than the basal segment of scape.

Pronotum dark, reddish medially. Mesonotal præscutum polished coal-black, the stripes smooth, the interspaces coarsely punctate; scutum with the centers of the lobes smooth, the median region punctate; scutellum metallic blue, punctate; postnotum black, punctate. Pleura black, coarsely punctured, the sternopleurite nearly smooth, without punctures; dorsopleural region conspicuously pale yellowish white. Halteres brownish black, the base of the stem restrictedly pale. Legs with the

coxæ obscure yellow, slightly infuscated basally; trochanters yellow; femora brownish black, the bases paler, the tips darker; tibiæ and tarsi black. Wings (Plate 1, fig. 6) with a faint dusky tinge, the prearcular and costal regions more blackened; veins black. Venation: Sc_1 lacking; Sc_2 ending just beyond midlength of Rs, the free tip a short distance before R_{2+3}; r-m connecting with Rs before fork; R_{2+3} oblique; R_{1+2} entirely atrophied; cell M_2 open by atrophy of m, in one wing of type this crossvein indicated by a weak trace; m-cu oblique, more than its length beyond the fork of M and nearly equal to the distal section of Cu_1.

Abdominal tergites black, the outer segments paling to brown; sternites obscure yellow; hypopygium yellowish brown.

LUZON, Laguna Province, above Majayjay, Mount Banahao, May 10, 1929 (*A. C. Duyag*) ; holotype, male.

The discovery of a cylindrotomine fly in the Philippines is of great interest. The nearest ally is *S. quadricellula* (Brunetti) of India, which differs especially in the larger size, the coloration of the body, and the venation.

LIMONIINÆ

LIMONIINI

LIMONIA (LIBNOTES) CARBONIPES sp. nov.

General coloration orange, the terminal two segments of the abdomen black; legs and halteres black; wings with a strong brown tinge, bordered with darker, most intense in the prearcular and costal regions.

Male.—Length, about 10 to 11 millimeters; wing, 11.5 to 14.

Rostrum brown; palpi black. Antennal scape black; flagellum broken. Head fiery orange, the anterior vertex narrower than the first scapal segment.

Thorax entirely deep orange, including the coxæ and trochanters. Halteres and legs black, only the extreme bases of the femora obscure yellow. Wings with a strong brown tinge, the prearcular and costal regions more blackish; wing apex and a border along the posterior margin infumed, entering the cells as scattered black dots.

Abdomen orange; segments eight and nine, with the remainder of the hypopygium, deep black.

LUZON, Laguna Province, Ube, Mount Banahao, May 29, 1929 (*R. C. McGregor*) ; holotype, male; Majayjay, June 8, 1929 (*R. C. McGregor*) ; paratype, male.

Although it is in general similar to *L.* (*L.*) *termitina* (Osten Sacken), I must regard the present species as distinct. The black coloration of the legs and halteres of *carbonipes* provides the most conspicuous characters for the separation of the two forms.

LIMONIA (LIBNOTES) ACROPHÆA sp. nov. Plate 1, fig. 7.

Thorax fulvous; head black; halteres dark brown; legs brownish yellow, the tips of the femora infuscated; wings dusky, the apex more strongly infumed; Sc_1 subequal to Rs; cell 1st M_2 relatively small, shorter than any of the veins beyond it.

Female.—Length, about 7 millimeters; wing, 7.3.

Rostrum and palpi brownish black. Antennæ black. Head black, the orbits very narrowly margined with paler; anterior vertex reduced to a narrow strip.

Pronotum black. Mesonotum almost uniformly fulvous, the scutellum slightly more yellowish, the postnotum a trifle darker. Pleura fulvous-yellow. Halteres dark brown; Legs with the coxæ and trochanters yellow; femora yellow, the tips broadly infuscated tibiæ brown; tarsi more yellowish brown. Wings (Plate 1, fig. 7) with a faint dusky tinge, the apex, especially in the outer radial cells, more strongly infumed; stigma irregularly triangular, darker brown; cell Sc and a seam along vein Cu_1 in cell M dusky; veins dark brown. Venation: Sc_1 ending about opposite r-m, Sc_2 very far from its tip, Sc_1 subequal to Rs; free tip of Sc_2 and R_2 in transverse alignment; cell 1st M_2 relatively small, shorter than any of the veins beyond it; m-cu from two-thirds to nearly its own length beyond the fork of M; vein 2d A nearly straight, diverging gradually from 1st A.

Abdominal tergites dark brown, the sternites abruptly light yellow. Ovipositor with the tergal valves slender, gently upcurved; sternal valves stouter and nearly straight.

LUZON, Laguna Province, Ube, May 18, 1929 (*A. C. Duyag*); holotype, female.

By Edwards's key to the species of *Libnotes*[3] the present species runs out at couplet 55, differing in the wing coloration, the apex being strongly infumed. The long Sc_1 and small cell 1st M_2 are noteworthy characters.

LIMONIA (LIMONIA) LUTEIVITTATA sp. nov. Plate 1, fig. 8.

General coloration dark brown, the præscutum with three ocherous-yellow stripes; centers of the scutal lobes similarly

[3] Journ. Fed. Malay States Mus. 14 (1928) 74–80.

yellow; pleura with a dark longitudinal stripe; legs brown, the tarsi paler; wings with a strong brown tinge, sparsely patterned with darker brown; free tip of Sc_2 lying basad of R_2 a distance nearly equal to its own length.

Female.—Length, about 5.5 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ black; basal flagellar segments subglobular, soon passing into oval and finally elongate; verticils unilaterally arranged, chiefly in pairs, exceeding the segments. Head black; anterior vertex relatively wide, nearly twice the diameter of the first scapal segment.

Pronotum brown. Mesonotal præscutum with the ground color dark brown, with three conspicuous ocher-yellow stripes, their surface shiny; median stripe on anterior half very indistinctly divided by a capillary dark vitta; scutal lobes ocherous, their mesal and lateral margins with a narrow dark brown line; scutellum dusky; postnotal mediotergite brown, darker brown laterally. Pleura obscure ocherous, with a conspicuous dark brown longitudinal stripe. Halteres brown, the base of the stem narrowly yellow, the knobs blackened. Legs with the coxæ obscure brownish yellow; trochanters yellow; femora brown, their bases slightly paler; tibiæ brown, the tarsi paling to obscure yellowish brown. Wings (Plate 1, fig. 8) with a strong brown suffusion; a sparse darker brown pattern, including seams at origin of Rs, fork of Sc, stigma, cord, and outer end of cell 1st M_2; wing apex conspicuously darkened; veins dark brown. Venation: Sc long, Sc_1 ending about opposite four-fifths the length of Rs, Sc_2 at its tip; Rs strongly arcuated at origin; free tip of Sc_2 lying nearly its own length basad of R_2; cell 1st M_2 a little widened outwardly, exceeding vein M_4 beyond it; m-cu at fork of M, exceeding the distal section of Cu_1.

Abdomen dark brown. Ovipositor with the tergal valves reddish horn color, relatively small and slender.

LUZON, Cagayan Province, Mount Crista, April, 1929 (*F. Rivera*); holotype, female.

Limonia luteivittata is readily told by the combination of diagnostic features listed above. The ocherous-yellow pattern on the dark brown mesonotum is very conspicuous.

LIMONIA (LIMONIA) MULTINODULOSA sp. nov. Plate 1, fig. 9; Plate 2, figs. 24, 25.

General coloration brownish yellow; antennæ (male) nodulose, the basal eleven flagellar segments with elongate glabrous apical necks; tarsi pale, the posterior tarsi and tips of the posterior

tibiæ snowy white; wings with a blackish suffusion; Sc long; male hypopygium with the ventral dististyle small, subglobular, the rostral prolongation long and slender.

Male.—Length, about 4.3 millimeters; wing, 5.

Rostrum and palpi black, the latter conspicuous. Antennæ (Plate 2, fig. 24) with the scapal segments brown, the flagellar segments dark brown; basal eleven flagellar segments enlarged, subtriangular, each with a long, glabrous, apical pedicel that is subequal in length to the enlarged basal portion; terminal segment elongate, about one-third longer than the entire penultimate segment, elongate-fusiform; flagellar segments with conspicuous outspreading setulæ and a single outstanding verticil, the latter unilaterally arranged. Head brown, the posterior vertex shiny black.

Mesonotal præscutum brownish yellow with a conspicuous median dark brown stripe and barely indicated pale brown lateral stripes; humeral region more yellowish; remainder of mesonotum brownish yellow. Pleura yellow. Halteres relatively long and slender, black. Legs with the coxæ and trochanters pale yellow; femora brown; tibiæ brown; fore and middle tarsi paling to dirty white; posterior legs stouter, the tips of the tibiæ and all the tarsi snowy white. Wings (Plate 1, fig. 9) with a strong blackish suffusion, the oval stigma darker brown; veins dark brown. Costal fringe relatively long and conspicuous. Venation: Sc long, Sc_1 extending to just before the fork of Rs, Sc_2 at its tip; basal section of R_{4+5} elongate, approximately two-thirds Rs; cell 1st M_2 closed, shorter than any of the veins beyond it; m-cu close to fork of M.

Abdomen dark brown, the sternites more testaceous-yellow; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 25) with the tergite, *9t*, transverse, each lobe with four long setæ near caudal margin, the median region produced into a depressed sheet that is densely set with setulæ. Basistyles, *b*, elongate, the ventromesal lobe at base. Dorsal dististyle, *dd*, a slender, gently curved rod. Ventral dististyle, *vd*, very small, subglobular, the rostral prolongation long and slender, nearly as long as the dorsal dististyle, without evident spines. Gonapophyses, *g*, with the mesal apical lobe long, of nearly equal width for the entire length.

LUZON, Laguna Province, above Ube, Mount Banahao, altitude 500 meters, September 1, 1929 (*R. C. McGregor*); holotype, male.

Limonia multinodulosa is quite distinct from other described regional species of the genus, the most notable features being the structure of the antennæ and male hypopygium.

LIMONIA (GERANOMYIA) PHŒNASPIS sp. nov. Plate 1, fig. 10; Plate 2, fig. 26.

General coloration of thorax reddish; rostrum black; legs brown, the tarsi paling to yellow; wings tinged with brownish, the stigma only slightly darker; Sc long; abdominal tergites dark brown, the sternites paler; male hypopygium with the two rostral spines of the ventral dististyle very elongate, arising from a single fleshy tubercle.

Male.—Length, excluding rostrum, about 4 to 4.2 millimeters; wing, 4 to 4.4; rostrum, about 1.5 to 1.6.

Rostrum of moderate length, black. Antennæ dark brown throughout; flagellar segments oval, the terminal segment a little smaller than the penultimate. Head gray; anterior vertex reduced to a mere line or with the eyes actually contiguous.

Thorax reddish, the pronotum and dorsopleural region slightly more infuscated. Halteres short, infuscated, the base of the stem narrowly paler. Legs with the coxæ and trochanters yellow; femora and tibiæ brown, the tarsi paling to yellow. Wings (Plate 1, fig. 10) tinged with brownish, the suboval stigma only slightly darker; veins brown. Venation: Sc_1 ending just beyond midlength of Rs, Sc_2 not far from its tip, Sc_1 alone a little less than R_2; cell 1st M_2 closed; m-cu some distance before the fork of M, shorter than the distal section of Cu_1.

Abdominal tergites and hypopygium dark brown; sternites obscure brownish yellow. Male hypopygium (Plate 2, fig. 26) with the tergite, 9*t*, transverse, the caudal margin with a very low emargination. Basistyle small. Dorsal dististyle a strongly curved sickle-shaped pale hook. Ventral dististyle, *vd*, very large and fleshy, the rostral prolongation slender, bearing a single very large and conspicuous fleshy tubercle that is larger than the prolongation itself; at apex of tubercle bearing two very long straight spines. Gonapophyses, *g*, with the mesal apical lobe a small acute spine.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; paratype, male.

Limonia (Geranomyia) phœnaspis is very distinct from all described members of the subgenus.

HELIUS (HELIUS) ARGYROSTERNA sp. nov. Plate 1, fig. 11; Plate 2, fig. 27.

General coloration black; femora dark brown, the tibiæ and tarsi white; wings tinged with brown, the costa and apex darker;

abdomen black, the sternites with silvery areas before caudal margin.

Male.—Length, about 5 to 5.5 millimeters; wing, 4.5 to 5.

Female.—Length, about 5 to 6 millimeters; wing, 4 to 5.3.

Rostrum black, of moderate length, a little exceeding the remainder of head; palpi black. Antennæ brownish black throughout; flagellar segments long-oval to subcylindrical, the verticils long and conspicuous. Head black.

Thorax black, the pteropleurite a little paler. Halteres black, the extreme base of the stem pale. Legs with the coxæ and trochanters brownish black; femora dark brown, paler basally; tibiæ and tarsi white. Wings (Plate 1, fig. 11) tinged with brown, the stigma, cells C and Sc, and wing apex more blackened; a vague longitudinal seam along vein Cu, with less distinct seams along most of the other longitudinal veins; veins dark brown. Venation: Sc_1 ending beyond the fork of Rs, Sc_2 at its tip; branches of Rs long but strongly divergent; cell 1st M_2 relatively small, all veins beyond it relatively elongate; m-cu at or close to fork of M; cell 2d A relatively narrow.

Abdominal tergites black, the bases of the segments a trifle paler; hypopygium black; sternites brown, the incisures blackened; a conspicuous silvery area on sternites two to seven inclusive, just before caudal margin. Male hypopygium (Plate 2, fig. 27) with the outer dististyle, *od*, only gently arcuated, the tip very weakly bifid. Inner dististyle, *id*, longer, the apex strongly curved. Basistyle with the mesal face provided with abundant erect setæ but without other armature. Ædeagus, *a*, elongate. Ovipositor with the base of the tergal valves black; valves very long and slender, nearly straight; sternal valves yellowish, stouter than the tergal valves.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; Mount Dos Cuernos, April, 1929 (*F. Rivera*); allotype, female. Paratypes, one male with the type; one male with the allotype; one male, Ube, Laguna Province, May 18, 1929 (*A. C. Duyag*).

Helius argyrosterna is very distinct from all regional species.

ORIMARGA PERPICTULA sp. nov. Plate 1, fig. 12; Plate 2, fig. 28.

General coloration ocherous; lateral margins of præscutum and the pleura heavily silvery pruinose; legs yellow, the femoral tips broadly, the tibiæ very narrowly darkened; wings broad, pale yellow, with a heavy brownish gray clouding; Sc and 2d A long.

Male.—Length, about 4.8 millimeters; wing, 3.

Rostrum reddish; palpi darker. Antennæ black, the outer segments of the flagellum paler; flagellar segments nearly globular, decreasing in size and becoming more elongate outwardly. Head chiefly dark brown.

Mesonotum light ocherous, the præscutum with a capillary black median vitta on the anterior half; humeral and lateral regions silvery pruinose; postnotal mediotergite somewhat darker. Pleura chiefly dark brown, the surface heavily pruinose with silvery. Halteres orange-yellow, the central portion of the stem more dusky. Legs with the coxæ reddish, narrowly darkened at bases; trochanters reddish; femora yellow, the tips conspicuously brownish black; tibiæ yellow, the tips narrowly infuscated; tarsi yellow. Wings (Plate 1, fig. 12) unusually broad for a member of this genus; ground color creamy, the surface heavily variegated with brownish gray clouds, placed at arculus, origin of Rs, fork of Sc, along the irregular cord, tip of R_3, m-cu and as conspicuous seams on M, 1st A and in cell 1st A near the angulation of vein 2d A; conspicuous marginal darkenings at ends of the longitudinal veins; veins yellow, blackened in the clouded areas, C brighter yellow. Costal fringe very long and conspicuous, yellow. Macrotrichia of veins unusually sparse, the only ones in the radial field being a close series on the distal half of R_{4+5}. Venation: Sc much longer than in *O. pictula*, Sc_1 extending to shortly beyond m-cu, Sc_2 at its tip; Rs angulated at origin; R_1 extending very close to the incrassated costa, very faint and pale to almost obsolete; R_3 angulated and spurred at outer end; basal section of R_{4+5} strongly arcuated to weakly angulated before midlength; cell M_3 relatively deep, vein M_4 exceeding vein M_{3+4}; vein 2d A unusually long for an *Orimarga*, ending opposite the angulation of Rs; anal field unusually expanded.

Abdomen light orange-brown, the sternites slightly more yellowish, the lateral margins narrowly dusky; hypopygium pale. Male hypopygium (Plate 2, fig. 28) with the outer dististyle, *od*, a long, gently curved, blackened rod, the tip acute. Inner dististyle of approximately equal length, slender, pale, with conspicuous setæ, including a group of four small tubercles before midlength.

LUZON, Laguna Province, Ube, May 20, 1929 (*A. C. Duyag*); holotype, male; Mount Maquiling (*C. F. Baker*), a fragmentary paratype male.

Allied to *Orimarga pictula* Edwards (Key Islands), differing especially in the details of venation, notably the longer Sc and 2d A. The dilation of the anal field somewhat suggests the more-accentuated condition in the allied Ethiopian genus *Protorimarga* Alexander.

HEXATOMINI

EPIPHRAGMA CRENULATA sp. nov. Plate 1, fig. 13; Plate 2, fig. 29.

General coloration of mesonotum ashy gray; remainder of body chiefly yellow; basal segments of antennæ pale yellow, the remainder dark; basal two or three flagellar segments united into a single fusion segment; legs yellow; wings light brown, the costal margin clearer yellow; axillary margin crenulate; a series of supernumerary crossveins in costal cell; a supernumerary crossvein in cell Cu; m-cu close to the fork of M; male hypopygium with the interbasal process bilobed at apex.

Male.—Length, about 6.5 millimeters; wing, 6.

Female.—Length, about 8 millimeters; wing, 6.5.

Rostrum brownish gray; palpi brown, small, apparently reduced in number of segments. Antennæ with the scapal segments very pale yellow to dirty white; basal fusion segment of flagellum yellowish white; remainder of flagellum brown; antennæ short in both sexes; a distinct fusion segment at origin of flagellum, involving flagellar segments one and two and a partial fusion of segment three, more complete in the male; verticils longer than the segments, lacking on the scapal and fusion segments. Head with the anterior vertex ashy gray, the posterior vertex yellowish brown with a darker central area.

Mesonotal præscutum flattened, the dorsal portion abruptly light ashy gray, the humeral and lateral portions orange-yellow, the two colors narrowly delimited by a brownish line; transverse suture yellow, the lateral portions poorly defined; scutum light ashy gray; scutellum more brownish gray; postnotal mediotergite dark, slightly pruinose, the lateral portions obscure yellow. Pleura and pleurotergite light yellow. Halteres relatively elongate, pale yellow, the knobs weakly infuscated. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips slightly paler yellow; tibiæ and tarsi pale yellow, only the outer segments of the latter darkened. Wings (Plate 1, fig. 13) with a light brown tinge, the prearcular and costal regions light yellow, the latter continued around the margin to beyond the wing tip, but interrupted by conspicuous brown spots at ends

of the longitudinal veins; very narrow dusky seams on all crossveins and deflections of veins, in addition to a series of reduced marginal dots on the medial veins and all veins caudad of these; veins brown, more yellowish in the flavous areas. Axillary region of wing conspicuously incised, producing a rounded basal lobe. Venation: A series of from five to nine supernumerary crossveins in cell C; m-cu close to the fork of M; a supernumerary crossvein in cell Cu, immediately basad of the level of origin of Rs.

Abdomen pale brownish yellow, the sternites brighter yellow; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 29) with the outer dististyle, *od,* terminating in a curved chitinized point. Interbasal process, *i,* of moderate length, bilobed at apex.

LUZON, Cagayan Province, Mount Tabuan, May, 1929 (*F. Rivera*); holotype, male; allotype, female.

Epiphragma crenulata is a strikingly distinct species. At first sight, the characters of a fusion segment involving the basal segments of the antennal flagellum, the incised axillary region of the wing, and the presence of a supernumerary crossvein in cell Cu would appear to warrant the erection of a new generic or subgeneric group. However, most of these characters are presaged or indicated in other Philippine species of the genus, especially the antennal fusion and presence of a supernumerary crossvein in cell Cu. The various subspecies of *Epiphragma bakeri* Alexander, as defined in the preceding part under this general title,[4] will probably be found to warrant full specific rank. This is certainly the case with *Epiphragma ochrinota* Alexander, a male of which was taken at Ube, altitude 500 meters, August 30, 1929, by Rivera, and which has the interbasal process of entirely different form from the other species, being elongate and gradually narrowed into an acute sinuous spine. This species, among others, shows an evanescent supernumerary crossvein in cell Cu.

PSEUDOLIMNOPHILA LUTEITARSIS sp. nov. Plate 1, fig. 14; Plate 2, fig. 30.

General coloration of mesonotum brown; antennæ black throughout; legs black, all tarsi extensively pale yellow; wings relatively narrow, with a brownish tinge; a supernumerary crossvein in cell Sc immediately basad of origin of Rs; m-cu from one-third to one-half its length beyond the fork of M.

[4] Philip. Journ. Sci. 41 (1930) 303.

Male.—Length, about 5.5 millimeters; wing, 5.2.

Rostrum black; palpi reduced, black. Antennæ black throughout; flagellar segments long-cylindrical, passing into setaceous, the verticils relatively short and inconspicuous. Head blackened.

Mesonotal præscutum light yellowish brown, the humeral region clearer yellow; posterior sclerites of mesonotum somewhat darker brown. Pleura obscure yellow. Halteres dark brown, the base of the stem restrictedly paler. Legs with the coxæ and trochanters yellow; femora and tibiæ brown; tarsi brown, the tips of the basitarsi and segments two and three pale yellow; two terminal tarsal segments darkened; legs long and slender, the tarsi exceeding the tibiæ. Wings (Plate 1, fig. 14) relatively narrow, tinged with brown, cells C and Sc, together with the small narrow stigma, slightly darker brown; veins dark brown. Venation: Sc_1 ending shortly beyond the fork of Rs, Sc_2 a short distance from its tip; a supernumerary crossvein in cell Sc immediately before origin of Rs; R_{2+3+} arcuated; R_{1+2} approximately three times R_2 alone; inner end of cell R_3 pointed; cell M_1 present, longer than its petiole; m-cu from one-third to one-half its length beyond the fork of M; anterior arculus preserved.

Abdomen light brown, the sternites more yellowish; a darker subterminal ring; hypopygium chiefly obscure yellow. Male hypopygium (Plate 2, fig. 30) with the outer dististyle, *od,* unusually long and slender, the tip extended into a gently curved spine, the surface of the style roughened. Inner dististyle nearly as long, cylindrical, the extreme tip suddenly narrowed. Phallosome produced into a two-horned pale plate on either side.

LUZON, Rizal Province, Santa Ines, December, 1926 (*Rivera and Duyag*); holotype, male.

Pseudolimnophila luteitarsis is very distinct from other regional species of the genus. It is possible that the character and position of a supernumerary crossvein in cell Sc is not constant, since it is not known in any other species of *Pseudolimnophila.*

ERIOPTERINI

GONOMYIA (LIPOPHLEPS) BICOLORATA sp. nov. Plate 1, fig. 15; Plate 2, fig. 31.

Head yellow; mesonotum dark brown; thoracic pleura striped; legs dark brown; wings with a strong blackish suffusion, the costal margin abruptly pale yellow; Sc short, Sc_1 ending before

Rs a distance greater than the length of that vein; male hypopygium with the inner dististyle produced into a long needlelike spine.

Male.—Length, about 2.5 millimeters; wing, 3.1.

Rostrum and palpi black. Antennæ with the scapal segments sulphur yellow, more dusky beneath; flagellum broken. Head light yellow, the center of the vertex with a dusky spot.

Anterior lateral pretergites pale yellow. Mesonotal præscutum and scutum dark brown, the extreme lateral margins of the former pale yellow; scutellum obscure brownish yellow, darker medially at base; postnotal mediotergite dark brown, with a yellow area on either side. Pleura dark brown, with a conspicuous longitudinal China white stripe extending from the fore coxæ to beneath the haltere; dorsal pleurites more yellowish brown. Halteres chiefly dusky, the lower surface of the stem light sulphur yellow. Legs with the fore coxæ China white, as above described, the remaining coxæ chiefly darkened, paler apically; trochanters brown; remainder of legs dark brown. Wings (Plate 1, fig. 15) with a strong blackish suffusion, the costal region abruptly light yellow; stigma darker brown than the ground color, preceded and followed by more whitish areas, the former crossing cell R_2 into cell R; other vague pale areas beyond the cord and in the anal field; veins brown, paler in the costal area. Venation: Sc short, Sc_1 ending far before Rs, the distance a little greater than the length of the latter vein; m-cu a short distance before the fork of M.

Abdominal tergites dark brown, the posterolateral portions of the segments vaguely and narrowly obscure yellow; sternites brighter in color. Male hypopygium (Plate 2, fig. 31) with the outer dististyle, *od*, consisting of two connate arms, the outer a long gently arcuated rod, the distal half blackened, at about the basal fourth bearing a slender blackened rod that is weakly notched at apex; inner arm closely applied or fused for approximately one-half the length of the outer style, the free portion bent at about a right angle or more, at apex dilated into a rounded head, the surface of the stem and knob clothed with abundant yellow setæ. Inner dististyle, *id*, an elongate-oval setiferous lobe, the apex produced into a very long pale spine, the acute tip narrowly blackened. Ædeagus, *a*, very slender, curved, subtended on either side by the spatulate gonapophyses.

LUZON, Laguna Province, Ube, Mount Banahao, May 19, 1929 (*A. C. Duyag*); holotype, male.

Gonomyia bicolorata is very distinct from all regional species. It is most similar to *G.* (*L.*) *hackeri* Edwards (Pahang), differing in the darker color of the wings and especially the very distinct male hypopygium.

Genus TRENTEPOHLIA Bigot

The number of known Philippine species of *Trentepohlia* has more than doubled since the publication of the last key to the species.[5] The species now known to inhabit the Islands may be separated by means of the following key:

1. Cell 1st M_2 closed .... 2.
   Cell 1st M_2 open by the atrophy of m and the two distal sections of M_3. (Subgenus *Trentepohlia* Bigot.) .... 11.
2. Two branches of M reach the margin; veins Cu_1 and 1st A widely separated at margin. (Subgenus *Paramongoma* Brunetti.) *T. banahaoensis* Alexander.
   Three branches of M reach the margin; veins Cu_1 and 1st A fused for a distance back from the margin (in all Philippine species). (Subgenus *Mongoma* Westwood.) .... 3.
3. Tips of femora abruptly and conspicuously whitened .... 4.
   Femora black or pale, with the tips blackened .... 6.
4. Crossvein m-cu at or beyond midlength of cell 1st M_2; tibiæ with a dark subbasal ring .... *T. duyagi* sp. nov.
   Crossvein m-cu at or before the fork of M; tibiæ obscure whitish, without distinct darkening .... 5.
5. R_2 subequal to R_{3+4}; R_3 strongly arcuated, cell R_3 widened at base. *T. saxatilis* Alexander.
   R_2 close to fork of R_{3+4}, the latter thus much reduced; R_3 not conspicuously widened at base .... *T. tenera* (Osten Sacken).
6. Femora beyond base uniformly darkened .... 7.
   Femora pale, in cases with the tips narrowly brown or black .... 9.
7. All tibiæ white at tips, the mid-tibiæ with distal ends feathered. *T. pennipes* (Osten Sacken).
   Tibiæ without whitened tips; no tibiæ with apical feathering .... 8.
8. Vein R_3 strongly arcuated; cell R_5 longer than M_3, the fusion between veins R_5 and M_{1+2} relatively short, less than the second section of M_{1+2} .... *T. brevifusa* sp. nov.
   Vein R_3 nearly straight; fusion between veins R_5 and M_{1+2} long, exceeding twice the second section of M_3 .... *T. riverai* sp. nov.
9. General coloration pale yellow, this including the legs and wings. *T. poliocephala* Alexander.
   General coloration of body and legs not pale yellow .... 10.
10. Crossvein m-cu beneath cell 1st M_2; all femora and tibiæ narrowly tipped with black .... *T. ricardi* Alexander.

[5] Philip. Journ. Sci. 33 (1927) 302.

Crossvein m-cu at or close to fork of M; all femora narrowly infumed at tips; fore tibiæ with tips broadly blackened, hind tibiæ with tips more broadly whitened .... *T. luzonensis* Edwards.

11. Tips of femora abruptly whitened .... *T. bakeri* Alexander.
Femora either uniformly pale in color or with the tips narrowly blackened .... 12.

12. Tips of femora and tibiæ conspicuously blackened; wings yellow, unmarked, except for a narrow seam on vein R_3. *T. mcgregori* Alexander.
Femora uniformly pale in color; wings not patterned as above .... 13.

13. Wings almost immaculate, only the costal portion broadly suffused with yellow .... *T. holoxantha* Alexander.
Wings with a conspicuous brown pattern .... 14.

14. Abdomen reddish, the terminal segments black; wings yellowish subhyaline, the apex dark brown; cord narrowly seamed with brown but not suffusing cell R_1 .... *T. trentepohlii* (Wiedemann).
Abdomen entirely black; a dark brown costal area at sector and in cell R_1, in addition to the darkened apex .... *T. pictipennis* (Bezzi).

TRENTEPOHLIA (MONGOMA) DUYAGI sp. nov. Plate 1, fig. 16.

General coloration brown; femora black, the tips narrowly and abruptly light yellow; tibial bases more narrowly pale, followed by a black ring, this broadest on the forelegs, narrowest on the posterior legs; tarsi pale yellow; wings tinged with brown, the costal region more brownish yellow; R_2 at fork of R_{3+4}, cell R_3 large; m-cu beyond midlength of the small cell 1st M_2.

Male.—Length, about 9 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ with the first segment of scape black, the succeeding segments brown; flagellar segments cylindrical, the verticils very short and inconspicuous. Head black, sparsely pruinose; anterior vertex very narrow.

Mesonotum yellowish brown, the præscutum with the interspaces darker; median region of scutum and the scutellum obscure yellow; postnotum dark brown, vaguely marked with paler. Pleura more yellowish, darker dorsally. Halteres dark brown, the base of the stem narrowly pale. Legs with the coxæ obscure yellow; trochanters yellow; femora brownish black, the tips narrowly and abruptly light yellow; bases of tibiæ similarly but more narrowly white, followed by a black ring of various lengths, on the forelegs including more than one-half the segment, gradually paling to yellow at tips; this dark ring is narrower on the other legs, presumably narrowest on the hind tibiæ (legs detached) where it is distinct only as a narrow subbasal ring; tarsi pale yellow; legs without special armature. Wings (Plate 1, fig. 16) with a strong brown tinge, the prearcular and

costal regions more brownish yellow; stigma elongate, slightly darker brown; wing apex narrowly infumed; vague seams on certain of the longitudinal veins, especially R_4 and Cu_1; axilla and tip of vein 2d A darkened; veins black, paler in the costal region. Venation: R_2 at fork of R_{3+4}, cell R_3 unusually large; cells R_5 and M_3 subequal in length; cell 1st M_2 small, with m-cu beyond midlength; apical fusion of Cu_1 and 1st A slight.

Abdominal tergites light brown, narrowly dark brown laterally; a vague yellow sublateral area on either side before the caudal margin; sternites obscure yellow; hypopygium light brown.

LUZON, Laguna Province, Ube, Mount Banahao, May 18, 1929 (*A. C. Duyag*); holotype, male.

I take great pleasure in naming the species after the collector, Mr. A. C. Duyag, who has added materially to our knowledge of the Philippine crane flies. No very close allies of the fly can be indicated. The position of m-cu beneath cell 1st M_2 is an uncommon feature in the subgenus.

TRENTEPOHLIA (MONGOMA) RIVERAI sp. nov. Plate 1, fig. 17.

General coloration dark brown; legs black, the tarsi paling to yellow; legs relatively short, the tarsi less than the tibiæ; wings tinged with gray, cells C and Sc, together with the wing tip, restrictedly darkened; fusion of Cu_1 and 1st A very slight.

Female.—Length, about 5.5 millimeters; wing, 5.

Rostrum and palpi brown, the labial palpi more yellowish. Antennæ brownish black throughout. Head black.

Mesonotal præscutum uniformly dark brown, the posterior sclerites of the mesonotum more testaceous brown, the postnotum again darkened. Pleura brownish yellow, variegated with brown on the anepisternum. (Halteres broken.) Legs with the coxæ and trochanters yellow; femora and tibiæ black, the tarsi paling to yellow; posterior basitarsi with a long black bristle at base; legs relatively short, the tarsi shorter than either the femora or tibiæ, especially the posterior tarsi. Wings (Plate 1, fig. 17) with a slight gray tinge, cells C and Sc and the wing tip restrictedly darkened; a slight darkening between the anal veins near base; veins brown. Venation: Sc_1 ending a short distance before R_2; R_{2+3+4} about one-half longer than Rs; R_2 approximately equal to R_{3+4}; R_3 oblique, very gently sinuous, cell R_2 widest at margin; cell 1st M_2 small, the inner ends of cells R_5 and M_3 nearly on a level; m-cu at fork of M; apical fusion of Cu_1 and 1st A very slight to merely contiguous.

Abdominal tergites brownish black, the sternites more brownish yellow, darker laterally, the outer segments more uniformly darkened; ovipositor with the valves horn yellow.

LUZON, Cagayan Province, Peñablanca, Bauan, March, 1929 (*F. Rivera*); holotype, female.

The species is dedicated to Mr. Francisco Rivera, to whom we are greatly indebted for many interesting Tipulidæ from the Philippines. *Trentepohlia riverai* is most nearly allied to *T. atayal* Alexander (Formosa), differing in the coloration of the legs and details of venation.

TRENTEPOHLIA (MONGOMA) BREVIFUSA sp. nov. Plate 1, fig. 18.

General coloration dark brown; lateral præscutal stripes usually pale yellow; pleura obscure yellow, dark brown dorsally; legs long and slender, black, the tarsi paling to brownish yellow; wings tinged with brown, the costal region more blackened; vein R_3 arcuated, cell R_2 narrowed at margin; fusion of R_{4+5} and M_{1+2} unusually short.

Male.—Length, about 7 to 8 millimeters; wing, 6 to 7.

Female.—Length, about 8.5 to 9 millimeters; wing, 7.5 to 8.

Rostrum and labial palpi brownish yellow; maxillary palpi black. Antennæ black throughout; flagellar segments long-oval to truncate-fusiform, becoming more elongate outwardly. Head black; anterior vertex very narrow.

Pronotum brown. Mesonotal præscutum yellowish brown, darker medially, narrowly infuscated on lateral margins, the usual lateral stripes in cases pale yellow; remainder of mesonotum yellowish brown to brown, the median region of scutum obscure yellow. Pleura obscure yellow, the dorsal portions dark brown. Halteres brownish black. Legs with the coxæ and trochanters brownish testaceous; femora black, the bases restrictedly pale; tibiæ and tarsi black, the outer segments of the latter paling to brownish yellow; legs long and slender, the tibiæ longer than the femora, the tarsi longer than the tibiæ. Wings (Plate 1, fig. 18) with a brownish tinge, cells C and Sc more blackened; veins dark brown. Venation: Sc_1 ending shortly beyond the oblique R_2; R_{2+3+4} subequal to Rs; R_3 nearly perpendicular at origin, strongly arcuated, cell R_2 narrower at margin than at base; fusion of R_{4+5} and M_{1+2} usually short, varying from less than to subequal to the second section of M_{1+2}; cell R_5 longer than the other cells beyond cell 1st M_2; m-cu at or shortly beyond the fork of M; fusion of Cu_1 and 1st A slight; cell 2d A relatively short and wide.

Basal abdominal tergites obscure yellow, narrowly darkened laterally; succeeding tergites black, hypopygium brownish black; sternites obscure yellow.

LUZON, Cagayan Province, Mount Dos Cuernos, April, 1929 (*F. Rivera*); holotype, male; paratype, male; allotype, female, May, 1929; Mount Crista, April, 1929 (*F. Rivera*), paratype, female; Mount Tabuan, May, 1929 (*F. Rivera*), paratype, male.

The present species would seem to be most nearly allied to *T.* (*M.*) *saxatilis* Alexander.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *dd*, dorsal dististyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Tipulodina tabuanensis* sp. nov., wing.
2. *Tipulodina succinipennis* sp. nov., wing.
3. *Tipulodina cagayanensis* sp. nov., wing.
4. *Dolichopeza isolata* sp. nov., wing.
5. *Nesopeza angustaxillaris* sp. nov., wing.
6. *Stibadocera pumila* sp. nov., wing.
7. *Limonia* (*Libnotes*) *acrophæa* sp. nov., wing.
8. *Limonia* (*Limonia*) *luteivittata* sp. nov., wing.
9. *Limonia* (*Limonia*) *multinodulosa* sp. nov., wing.
10. *Limonia* (*Geranomyia*) *phœnaspis* sp. nov., wing.
11. *Helius* (*Helius*) *argyrosterna* sp. nov., wing.
12. *Orimarga perpictula* sp. nov., wing.
13. *Epiphragma crenulata* sp. nov., wing.
14. *Pseudolimnophila luteitarsis* sp. nov., wing.
15. *Gonomyia* (*Lipophleps*) *bicolorata* sp. nov., wing.
16. *Trentepohlia* (*Mongoma*) *duyagi* sp. nov., wing.
17. *Trentepohlia* (*Mongoma*) *riverai* sp. nov., wing.
18. *Trentepohlia* (*Mongoma*) *brevifusa* sp. nov., wing.

PLATE 2

FIG. 19. *Nesopeza annulitarsis* sp. nov., male hypopygium, lateral.
20. *Nesopeza annulitarsis* sp. nov., male hypopygium, ninth tergite.
21. *Nesopeza annulitarsis* sp. nov., male hypopygium, inner dististyle.
22. *Nesopeza angustaxillaris* sp. nov., male hypopygium, lateral.
23. *Nesopeza angustaxillaris* sp. nov., male hypopygium, ninth tergite.
24. *Limonia* (*Limonia*) *multinodulosa* sp. nov., antenna, male, segments 3 to 5, 12 to 14.
25. *Limonia* (*Limonia*) *multinodulosa* sp. nov., male hypopygium.
26. *Limonia* (*Geranomyia*) *phœnaspis* sp. nov., male hypopygium.
27. *Helius* (*Helius*) *argyrosterna* sp. nov., male hypopygium.
28. *Orimarga perpictula* sp. nov., male hypopygium.
29. *Epiphragma crenulata* sp. nov., male hypopygium.
30. *Pseudolimnophila luteitarsis* sp. nov., male hypopygium.
31. *Gonomyia* (*Lipophleps*) *bicolorata* sp. nov., male hypopygium.

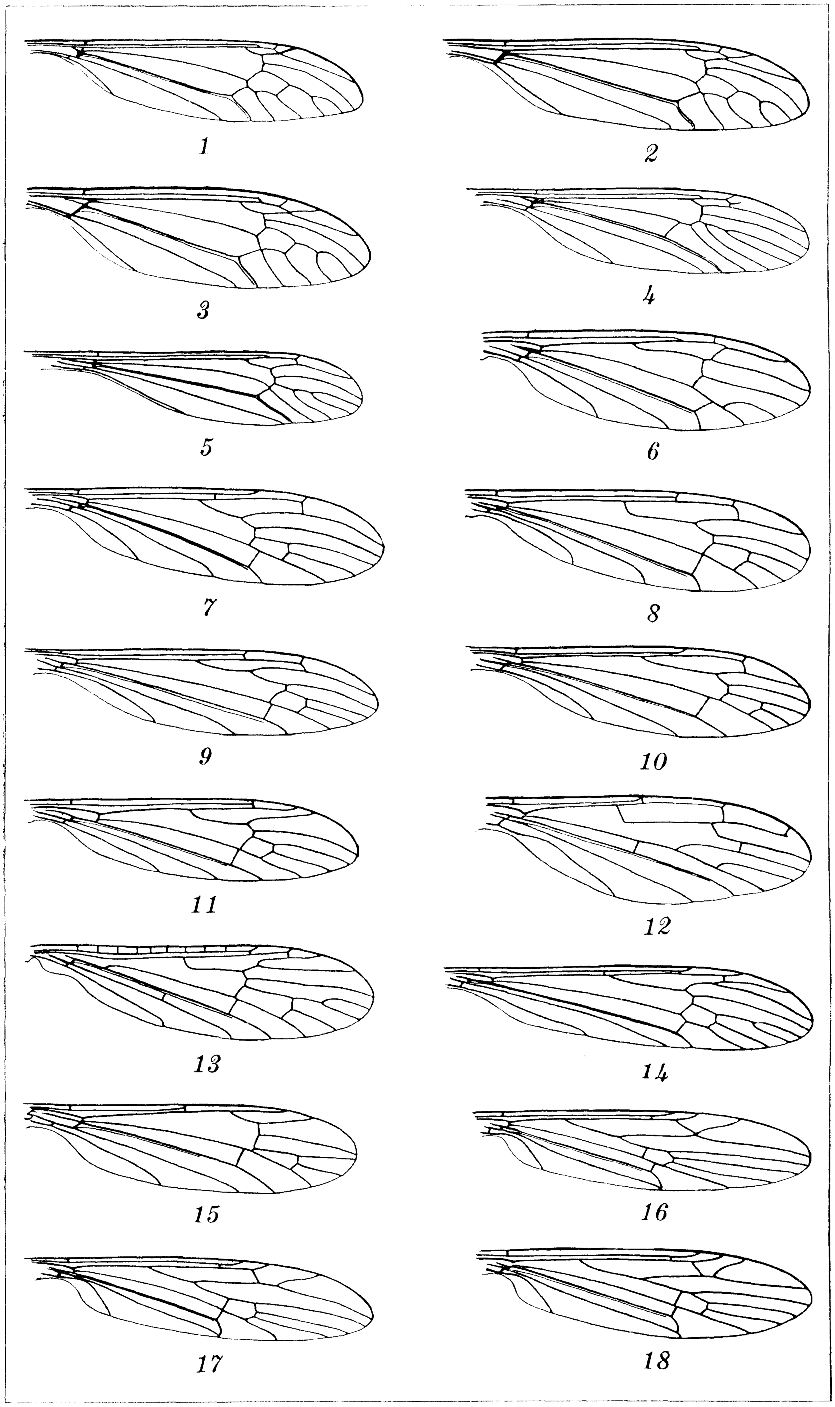

PLATE 1.

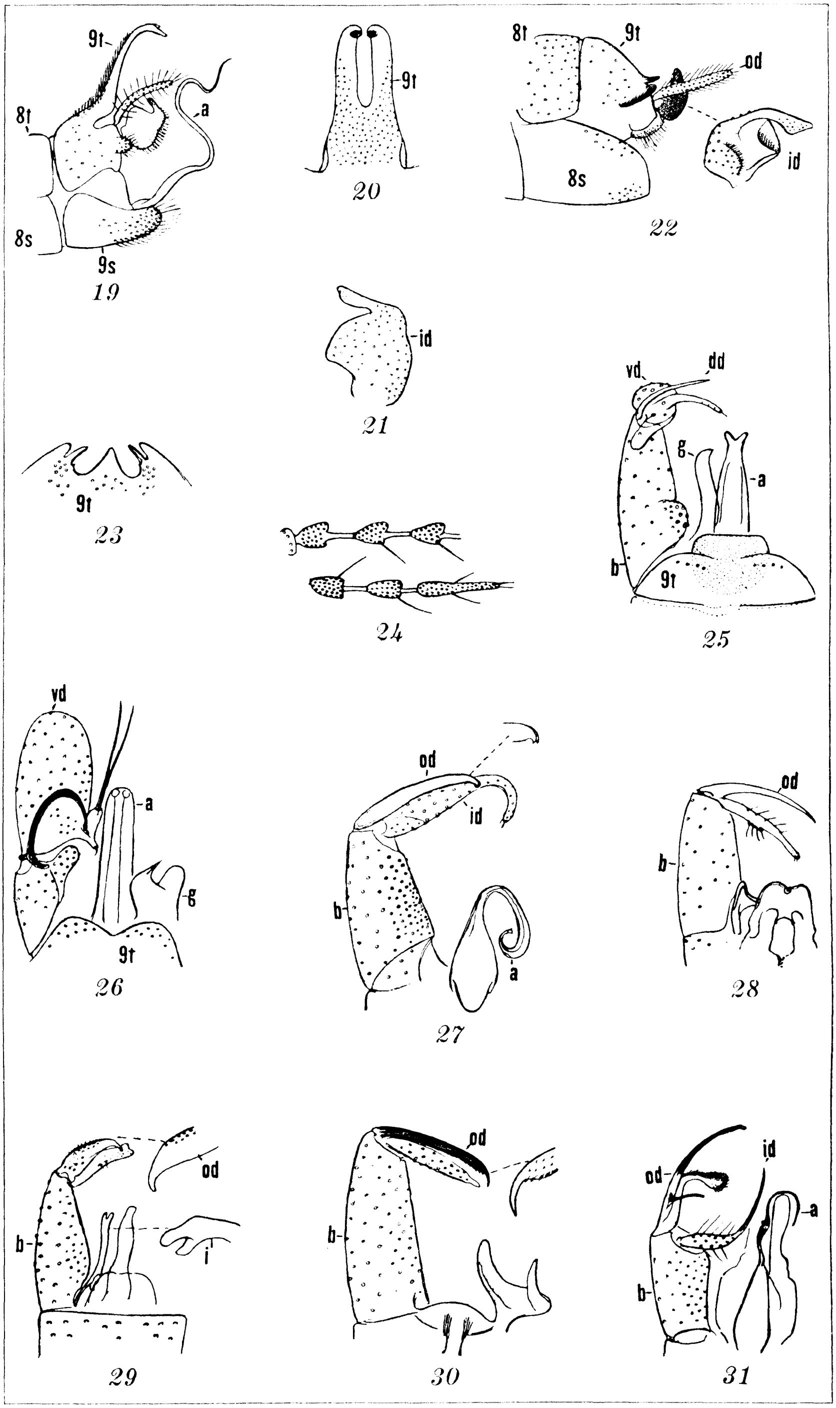
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PLATE 2.

LEAF AND BARK STRUCTURE OF SOME CINNAMON TREES WITH SPECIAL REFERENCE TO THE PHILIPPINE SPECIES

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TWENTY-ONE PLATES AND TWELVE TEXT FIGURES

The members of the genus *Cinnamomum* in general are characterized by the presence of oil and mucilage cells. They constitute a very interesting subject for anatomical study for they are very variable in height; in shape, size, and texture of the leaf; and also in the structure of their flowers. Many of the extreme forms of a given species are so different from one another that often they are considered to be distinct species, while a great number of the recognized species are so intimately connected by intermediate forms that it is very hard to find constant specific characters. In view of this, their external characteristics cannot always be taken as a fixed basis for accurate classification. Since the internal structure is much more constant and less affected by change of environment, any investigation concerning the anatomical structure of the parts, of the members of the genus *Cinnamomum,* will undoubtedly be of great value in throwing more light on the specific distinction of the individual species. This is especially true and important when it applies to the identification of the botanical source of certain parts of the plant, without flowers, used as drugs or medicines.

The number of species of *Cinnamomum* varies; according to Hooker(13) there are about one hundred thirty species of *Cinnamomum* distributed in tropical and subtropical eastern Asia, Australia, and the Pacific. The same number of species distributed more or less in the same regions are indicated by Cooke(5) and by Trimen.(21) Ridley,(19) however, believes that there are one hundred forty species in Indo-Malaya, China, Australia, and Polynesia. Bandulska,(3) on the other hand, in her recent article on a *Cinnamomum* from the Bournemouth

Eocene, claims that there are fifty-four living species of *Cinnamomum* belonging to tropical and eastern Asia and Australia.

In the Philippines Merrill (16) includes only seven species of *Cinnamomum* in his enumeration of Philippine plants and excludes six species. Quisumbing and Merrill (17) described recently two additional endemic Philippine species; namely, *C. microphyllum* and *C. trichophyllum*. The included species in the enumeration are *Cinnamomum mercadoi* Vid., *C. mindanaense* Elm., *C. myrianthum* Merr., *C. sandkuhlii* Merr., *C. zeylanicum* Blm., *C. burmanni* Blm. and *C. iners* Reinw. The first four are endemic, the rest are introduced and are only found in cultivation.

Cinnamomum zeylanicum and *C. cassia* were known universally from time immemorial as the plants yielding the essential oil that has been regarded as the most precious odoriferous substance. Some very interesting historical accounts about their highly priced barks are given by Flückiger and Hambury (9) and Dymock (6) in their respective Pharmacographias. Because of their great economic value, various adulterations and substitutions have been observed. Barks derived from related species, sometimes of inferior quality, are not infrequently sold as cinnamon or cassia lignea, because of their similarity in general appearance and odor. As an instance of this may be quoted the following statement of Flückiger and Hambury (9) with regard to cassia bark.

> Large quantities of a thick sort of cassia have at times been imported from Singapore and Batavia, much of which is produced in Sumatra. In the absence of any very reliable information as to its botanical sources, we may suggest as probable mother plants, *C. cassia* Bl. and *C. burmanni* Bl., var. *chinense*, both stated by Teijsmann and Binnendijk to be cultivated in Java. The latter species, growing also in the Philippines, most probably affords the cassia bark which is shipped from Manila.

The fact that the species *C. burmanni* Blm. var. *chinense*, indicated above, is not common in the Philippines, would suggest that the bark mentioned above by Flückiger and Hambury, shipped from Manila as cassia bark, might have been derived from *C. mindanaense*, a species very similar to *C. burmanni*. Merrill (16) has seen but a single Philippine specimen of *C. burmanni*, from Nagcarlang, Laguna Province, Luzon, and he believes that *C. mindanaense* is the probable species yielding the "cinnamon" exported from Mindanao in the early colonial period. This is quite in accord with the very important historical accounts published recently by Liquette (10) in a local magazine. These accounts are apparently strongly supported by authentic

documents and very reliable references. It is stated that the value of the Philippine cinnamon found growing in Cavite Point, or now known as Caldera Point, Mindanao, had been discovered as early as 1574 in which year about 430 quintals of cinnamon were brought to Manila by the Spaniards. Realizing the prospect and commercial value of the Mindanao cinnamon, they began to promote its cultivation and improve its quality. Various investigations were conducted. A number of samples of barks were sent to Spain for chemical analysis in order to find out how the abundant mucilage, which characterized the cinnamon from Mindanao, could be eliminated. During the administration of Governor Arandia (1754–1759) a large number of Philippine cinnamon trees were planted in Calauan, Laguna Province, Luzon, a place very close to Nagcarlang of the same province. It is quite probable that the plant seen by Doctor Merrill at Nagcarlang might have originated from one of the trees planted at Calauan.

The commonest species of cinnamon trees in the Philippines, long used as spices and as medicine, are *Cinnamomum mercadoi* Vid., which occurs more or less throughout the Islands, and *C. mindanaense* Elm. which is abundant in Mindanao and probably in some other places in the south.

Bacon,(1, 2) working on the chemical constituents of the two Philippine cinnamon plants, observed that the oil from *Cinnamomum mercadoi* consists almost entirely of safrol, which he considers a remarkable thing, as most oils from cinnamon species contain only small amounts of safrol and a large percentage of cinnamic aldehyde; while in *C. mindanaense* he obtained an oil of yellow color and of a strong cinnamic odor and taste with about 60 per cent of cinnamic aldehyde.

As to the internal structure of the parts of the members of this genus there are, so far, only two species where barks have been described by Greenish,(12) Bentley and Trimen,(4) Flückiger and Hambury,(9) Dymock,(6) Reutter,(18) and others. These species are *C. zeylanicum* and *C. cassia.*

Recently Bandulska(3) has published an article describing the cuticular structure of the leaves of *Cinnamomum camphora* Nees and Eberm., *C. zeylanicum* Nees, and *C. burmanni* Blm., in connection with her investigation on a cinnamon from the Bournemouth Eocene.

MATERIAL AND METHODS

The material used in this investigation was obtained from various sources. The barks for the study of *Cinnamomum zey-*

lanicum and *C. cassia* were obtained from Parke Davis and Company, and also from the cultivated Ceylon cinnamon tree in the garden of the University of the Philippines. The bark of *Cinnamomum burmanni* came from the director of Buitenzorg Botanical Garden, Java, while the bark of *Cinnamomum mindanaense* was kindly given to me by Dr. P. Valenzuela, of the School of Pharmacy, University of the Philippines, this being a part of the material he got from Mindanao and from the bark brought by Mr. J. Fontanosa from Misamis, Mindanao. The specimen of *Cinnamomum mercadoi* was collected by Mr. V. Semilla, of the School of Forestry at Los Baños, Laguna Province, from a tree growing at the foot of Mount Maquiling, and the material of *Cinnamomum iners* was taken from the herbarium specimen collected by Dr. C. F. Baker, from Impolutao, Bukidnon, Mindanao.

The sections of the leaves were prepared from the herbarium specimens of the Bureau of Science. Samples from the different specimens of every species were taken and their corresponding sections were compared one with the other.

All the dried materials were placed in water for twenty-four hours before the sections were cut. This was done in order to render the material softer and consequently easier to cut in thinner sections. The fresh material or the material which had been preserved in 5 or 7 per cent formalin solution was cut directly without much difficulty.

The sections of the barks and of the leaves were prepared from 15 μ to 30 μ thick by means of a sliding microtome. Some of the sections were mounted in chloral hydrate solution, others in dilute solution of glycerin, and some were stained with safranin coupled with Delafield's hæmatoxylin and mounted in balsam.

For the study of the secretion cells containing essential oil the following stains were used: (*a*) Tincture of alkanna, which stains the oil content pink or red; (*b*) osmic acid solution, which gradually changes the color of the fixed oils from yellowish to dark brown or nearly black; and (*c*) Soudan red in glycerin, which by warming a section with it, colors the walls of the oil-secretion cells red. The following reagents were used for the special study of the secretion cells containing mucilage: (*a*) Solution of subacetate of lead, which renders the mucilage yellowish in color and makes it granular; or (*b*) a cubic centimeter of 10 per cent solution of lead acetate with a small amount of

ruthenium red, a mixture with a wine-red color, which sometimes stains the mucilage a brilliant pink.

The powder used for the study of *Cinnamomum zeylanicum* was taken from the Lilly's authentic powdered cinnamon bark, and the powder used for *C. mindanaense* was prepared in the laboratory of the School of Pharmacy, University of the Philippines.

Schultze's maceration mixture and methods as described by Greenish (11) were employed in the isolation and study of the individual cells.

CINNAMOMUM ZEYLANICUM BLUME

This moderate-sized evergreen tree is a native of Ceylon and India, grows in Burma and the Malay Peninsula, and is extensively cultivated in other tropical countries. It is one of the most variable species under the cinnamon group, and for this reason it has several synonyms. Meissner, (14) in de Candolle's Prodromus, describes six of its varieties. The tree is variable in height. The bark is reddish brown, rather thick and rough, and has longitudinal and transverse fissures. The young parts are slightly quadrangular, glabrous, with finely silky pubescent buds. The leaves are opposite or subopposite, petiolate, coriaceous, ovate or ovate-lanceolate with obtuse or rounded base, shortly acuminate or obtuse apex, and are strongly 3- to 5-nerved. The young leaves are bright pink or reddish and gradually become green. The panicles are large, terminal, much branched, usually about as long as the leaves, and mostly clustered in the upper axils. The flowers are numerous on rather long, slightly pubescent peduncles, pale yellow, small; the perianth about 7 millimeters long, pubescent outside with grayish hairs, tube short, campanulate, segment oblong-lanceolate, acute or obtuse, persistent. The fruit is about 1 centimeter long, oblong-ovoid, dry or slightly fleshy, dark purple, and surrounded by a much-enlarged perianth.

In the Philippines it is found occasionally cultivated in gardens in large towns, especially in Manila. On Plate 1, fig. 1, a portion of a branch, with flowers, from the tree growing in the garden of the University of the Philippines is represented.

THE LEAVES

General external morphological features.—Full-grown leaves of *Cinnamomum zeylanicum* are usually from 8 to 20 centi-

meters long by 3 to 8 centimeters wide at the widest part (text fig. 1). They are oblong-ovate or sometimes elliptical in outline, petiolate, trinerved, coriaceous, shining, bright green on the upper surface, glaucous beneath, with entire margin. The base is rounded or sometimes obtused, and the apex is bluntly acuminate. The petioles are from 8 to 14 millimeters in length, nearly cylindric and shallowly grooved on the upper part. The two basal lateral veins arising from the petiole may run parallel to the midrib up to 8 millimeters above the base and pass arch-wise towards the apex, but do not reach it. Few secondary veins may or may not be distinct. They usually branch

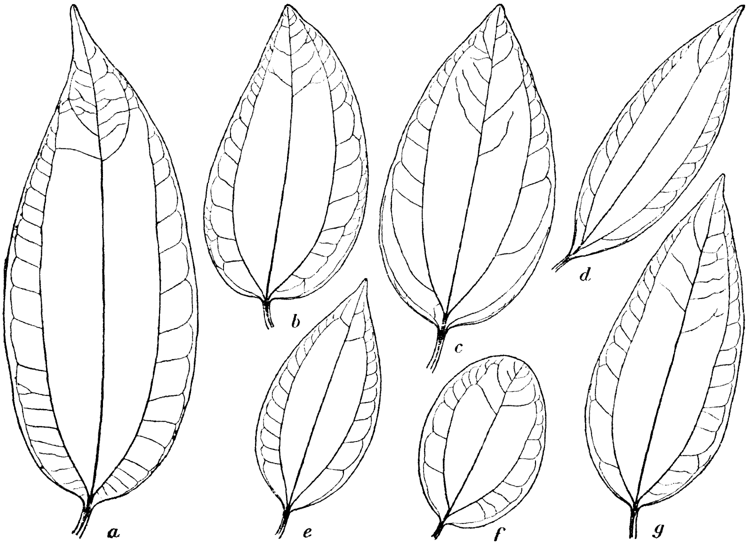

FIG. 1. *Cinnamomum zeylanicum*, average leaves from different specimens from the Philippines and abroad; *a*, from the garden of the University of the Philippines; *b* and *g*, from Tabogo, West Indies; *c*, from Tondo, Manila; *d*, from Bataan, Luzon; *e*, from Java. × ⅓.

and anastomose with each other, forming a sort of network. This anastomosing is more evident in the lower part of the leaf. When the fresh leaves are crushed between the fingers they give off an aromatic odor, characteristic and peculiar to the cinnamon trees. The taste is sweetish pungent and slightly astringent.

The internal structure of the leaf.—A transverse section of the lamina of a full-grown leaf measures about 0.3 millimeter in thickness and it is bifacial (text fig. 2, *b*). The upper epidermis consists of a single layer of rectangular or sometimes nearly

square and highly cutinized cells with very thick cell walls. Their cavities are greatly reduced and their walls are somewhat striated with depressions simulating simple pits. The lower epidermis is also composed of a single layer of cells of the same shape but thinner and with some stomata and oc-

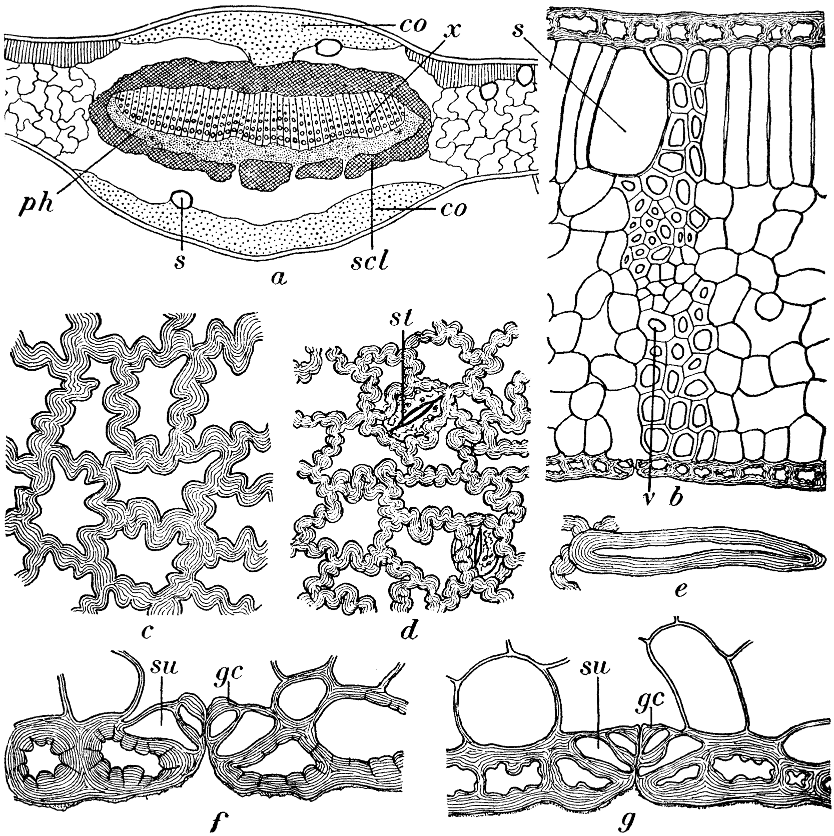

FIG. 2. *Cinnamomum zeylanicum; a,* diagrammatic representation of a transverse section of the midrib (*co,* collenchyma; *scl,* sclerenchyma; *ph,* phloëm; *x,* xylem; *s,* secretion cells); *b,* a segment of a transverse section of the blade (*s,* secretion cells; *v,* vein), × 250; *c,* a portion of the surface view of the upper epidermis, × 540; *d,* a portion of the surface view of the lower epidermis (*st,* stomata), × 540; *e,* a single hair, × 540; *f,* a portion of a transverse section of the lower epidermis showing a stoma from a specimen from Java (*gc,* guard cells; *sc,* subsidiary cells), × 700; *g,* a segment from a transverse section of the lower epidermis of a fresh leaf, × 700.

casionally with one or two unicellular hairs. The stomata appear mostly cut obliquely or sometimes longitudinally and a few transversally. The two small depressed guard cells forming the stoma are bordered and overarched by subsidiary cells which are arranged parallel to the pore and partly covered by inclosing epidermal cells (text fig. 2, *f* and *g*). There is

but one layer of straight-walled, cylindrical, palisade cells which are about 0.075 millimeter long and about 0.01 millimeter wide. Here and there are found large elliptical or rounded structures, between the palisade chlorenchyma or in the upper part of the spongy region, which are known as secretory cells. These secretory cells measure about 0.07 millimeter in length and about 0.045 millimeter in width. They usually contain essential oil and rarely mucilage. In some cases these secretory cells are also found in the lower part of the spongy region. The spongy chlorenchyma consists of irregularly shaped cells measuring usually about 0.035 millimeter in length and 0.012 millimeter in diameter with large intercellular spaces. Very often they have a brownish content. The veinlets are distributed at intervals, sometimes cut obliquely and sometimes transversally. They are vertically transcurrent on both sides by means of more or less differentiated sclerenchymatous cells. These cells have thick and slightly lignified walls with polygonal outline. The xylem region consists of a few small vessels or tracheids bounded in the lower part by a few phloëm cells.

The transverse section cut through the midrib reveals that it is more or less lenticular (text fig. 2, *a*). It is narrowly convex above and broadly convex below. The epidermis of each surface consists of a single layer of nearly rectangular or quadrangular cells with greatly thickened lateral walls and thick cuticles on the outer ones. Below the upper epidermis are collenchyma cells which are grouped in fan-shaped form with the lower, narrower portion extending towards the meristele. The two lateral sides are extended by means of two rows of cells towards the palisade regions. In the inner part of the lower epidermis there are also three or four layers of collenchyma cells stretched out from one side of the midrib to the other.

The parenchyma region just below the meristele is composed of about six or seven layers of thin-walled parenchyma cells with circular outlines and with small intercellular spaces. They contain few starch grains. Very often some secretory cells containing either essential oil or mucilage are found in this region. These secretory cells have the general appearance of the large parenchyma cells with thin walls, but the secretory cells are very much larger and usually contain essential oil or mucilage. The parenchyma in the upper part of the meristele consists of two patches, separated by the lower part of the collenchyma region, each of which is composed of two or three layers of rounded, thin-walled cells with small intercellular

spaces. Occasionally in these regions one or two secretory cells are also found. The meristele is somewhat lenticular in outline. In the outer part it is surrounded by two or three layers of faintly striated, slightly lignified, polygonal, and thick-walled sclerenchyma cells which are arranged in the form of a ring with two or three interruptions in its inner parts. The endodermis is not distinct. The phloëm region is confined to the lower part of the xylem region. The xylem vessels are arranged in radial rows and are from 0.015 to 0.03 millimeter in diameter.

Surface preparation.—The upper epidermis in surface view consists of cells varying from 0.025 to 0.04 millimeter in their greatest diameter and from 0.02 to 0.03 millimeter in their least diameter. They are polygonal in outline with sinuate and very thick cell walls, which measure about 0.007 millimeter and sometimes they are faintly striated (text fig. 2, *c*). The lower epidermis is also composed of more or less polygonal cells with very strongly convoluted cell walls about 0.004 millimeter in thickness. They measure from 0.02 to 0.04 millimeter in the greatest diameter and from 0.015 to 0.02 millimeter in the least (text fig. 2, *d*). Scattered in the lower epidermis there are numerous stomata and few simple unicellular hairs. The stomata are deeply located below the epidermis and partly covered by the neighboring epidermal cells which are five or six in number. They vary in size, and their outline is not quite distinct. The hairs are simple and unicellular with very thick walls (text fig. 2, *e*). They measure from 0.065 to 0.1 millimeter in length.

THE BARK

The fresh bark.—The bark, from the trunk of a tree about 10 years old, when fresh is from 5 to 10 millimeters thick. Externally it is brownish or dark brown, and sometimes greenish brown due to the presence of some pleurococcus. The outer surface is uneven, rough, and irregularly fissured. The outer layer of the cork region is somewhat easily separable. The middle part of the bark is granular on account of the groups of stone cells. The inner surface is creamy white, smooth, and soft. It gradually becomes brownish, especially when exposed to light. The bark is readily fractured by bending, and the fracture surface is uneven and gives an aromatic odor with a sweetish, pungent, and slightly astringent taste.

The fresh barks from branches from 2 to 5 centimeters in diameter or from a stem about 4 years old, are from 1 to 3 mil-

limeters thick. The external part is grayish brown to brownish or sometimes greenish brown like that from the trunk. The outer surface has slight, longitudinal fissures, with rounded or ovoid, dark brown lenticels. The inner surface, like the bark from the trunk, is creamy white, smooth, and soft. The fracture is incomplete, and the odor and taste are also like those of the bark of the trunk.

Commercial cinnamon bark.—Commercial bark is obtained in the form of sticks about 1 meter long, to 16 millimeters wide, and to about 1.2 millimeters thick (Plate 2, figs. 7, *a–d,* and 8). It consists of several overlapping quilled pieces of bark about 30 centimeters long. These quills of bark are deprived of the suberous coat and the greater part of the middle cortical region, and are arranged carefully one within the other, each side being made to curl inward, forming a somewhat cylindrical structure with a groove along one side. One account of this groove, formed by the incurving sides of the bark, in cross section the bark exhibits a reniform outline. The outer surface is light brown, smooth or rough, finely striated with shining slightly undulated lines and occasionally with branch scars or holes. The inner surface of the bark is dark. The fracture is very weak, brittle, and splintery or uneven. The odor and taste are like those of the fresh bark.

Microscopical structure.—A thin transverse section of fresh bark taken from a stem about 4 years old exhibits the following characteristics (Plate 3, fig. 9). The external part consists of a thin periderm which is composed of a single layer of highly cutinized epidermal cells, five to ten layers of thin-walled, slightly suberized, and tangentially flattened cork cells. The cork cells in one of the inner layers have thicker outer walls. The phellogen is not distinct, and the cortex is not sharply defined from the pericyclic region by starch sheath. The cortical part consists of ten to sixteen layers of tangentially elongated parenchyma cells. Some of these cells contain starch grains and others are filled with a brown substance. Intermingled with the inner layers of parenchyma cells a few characteristic cells more or less similar to the parenchyma cells are observed. These are the secretion cells (Plate 3, fig. 14). They differ from the parenchyma cells because they contain essential oil. They are also tangentially elongated and measure from 0.03 to 0.05 millimeter in their greatest diameter and from 0.015 to 0.02 millimeter in their least diameter. When

the secretion cells are treated with alkanna tincture, the contents of these secretion cells become red, while if treated with osmic acid solution their contents become brownish black which evidently proves that they contain essential oil.

The structure of the middle part of the bark, prepared from the fresh material, is the same as that of the section from the dried one of the commercial cinnamon bark (Plate 3, fig. 11). It is built up largely of tangentially elongated, sometimes rounded, thick-walled, pitted, sclerenchymatous stone cells. Their cavities are greatly reduced and sometimes contain starch grains. The inner walls of most of the stone cells are thicker than the outer ones. They measure from 0.05 to 0.12 millimeter in their longest diameter and 0.02 to 0.05 millimeter in their shortest diameter. In the outer part of the stone-cell ring there are one or two layers of tangentially elongated parenchyma cells containing few starch grains and interrupted by groups of small thick-walled cells with polygonal outline (Plate 3, fig. 10). These are the pericyclic fibers which correspond to the primary bast fibers, and they are the tissues that compose the wavy lines observed on the outer surface of the bark as indicated above (Plate 2, fig. 8). In the longitudinal section those sclerenchyma fibers are elongated and tapering at both ends and about 0.25 millimeter long. The inner part of the stone-cell ring is bounded by six to ten layers of parenchymatous, thin-walled, and tangentially elongated cells interrupted by parenchyma-like cells containing essential oils, and by larger cells containing mucilage (Plate 3, figs. 11 and 15). The parenchyma cells towards the phloëm region are smaller and are traversed by medullary ray cells. The medullary rays are mostly two cells wide, and the cells are nearly isodiametric. They have thin walls and in some parts are filled either with small, ovoid or somewhat rounded starch grains, or with minute prismatic or clinorhombic calcium oxalate crystals, or sometimes they are filled with a mixture of both calcium oxalate crystals and starch grains while some of the cells contain a brown substance. The starch grains measure about 0.003 millimeter in diameter, and the crystals of calcium oxalate about 0.0015 millimeter in width and 0.006 millimeter in length (Plate 3, fig. 13).

The remaining part of the section is the bast region, which occupies about one-half of the entire section of the peeled bark. It is composed of phloëm cells, parenchyma, bast fibers, and

secretory cells and is traversed by medullary rays one or two cells wide. Towards the sclerenchymatous ring the phloëm cells often collapse into strands, in which the cell cavities are scarcely visible; but towards the cambial region they appear tangentially elongated. The phloëm parenchyma cells are also, tangentially elongated and they may be rectangular or rounded, contain minute starch grains, and sometimes accompanied by tannic acid or small calcium oxalate crystals in raphides or clinorhombic forms. Scattered throughout the bast region there are conspicuous bast fibers, which are rounded, or four sided, and tangentially elongated, with very thick walls and greatly reduced cavities. They are isolated or in small, often radially arranged groups of three or four. The oil-secretion cells are also found scattered in the bast region, between the phloëm parenchyma cells. They can be easily recognized by their size. When the section is treated with Soudan red in glycerin and gradually warmed to the boiling point and then cooled, the suberized walls of the secretion cells become deep red.

In the radial section the stone cells appear either polygonal or rounded in outline and sometimes radially elongated as illustrated on Plate 3, figs. 12, 16, and 17. The medullary rays may consist of three to six rows of cells. The secretion cells are easily distinguished from the other cells because of their larger size and axially elongated shape. Some of these contain yellowish volatile oil or mucilage, some contain resin, and many are empty. The secretion cells may be observed isolated, or in groups of two, arranged one above the other. The sieve tubes are not distinct, except in a few cases where the transverse walls become prominently exposed. The phloëm parenchyma cells are mostly filled with starch grains and sometimes with few calcium oxalate crystals or with a brown substance. The bast fibers, as in the transverse section, are scattered and isolated or form groups of two or three cells. Their two ends are somewhat pointed.

The powder.—The bark of Ceylon cinnamon, in the powder form, is a light or yellowish brown and has a peculiar aromatic odor, characteristic of its essential oil. The most important elements found under the microscope in the examination of the powder are the bast fibers, the stone cells, secretion cells, the numerous small starch grains, fragments of the other tissues, and often the calcium oxalate crystals (Plate 4, fig. 18, *a–h*). The bast fibers with thick, slightly lignified walls, and spindle shaped are usually found alone or in groups of two, and in the

case of larger fragments they are embedded in a group of other cells. They measure from 0.10 millimeter to 0.800 millimeter in length and from 0.006 to 0.10 millimeter in width. The stone cells are numerous and occur either singly or in clusters of two or more cells. As in the cross-section, they are quite irregular in outline with very thick walls on one side and thinner on the other side. They are colorless, slightly striated, pitted, and contain either a brown amorphous substance or starch grains. The secretion cells are scanty and usually found in fragmentary form. When they are unbroken, they appear like ordinary parenchyma cells except that they are larger and when treated with alkanna tincture their contents become red or brownish red, and if they are treated with Soudan red in glycerin and warmed gradually to the boiling point, their suberized walls become red. The starch grains are numerous and they are either single or compound. The individual grains are spheroidal or polygonal and from 0.003 to 0.020 millimeter in diameter. Fragments of other tissues may consist of the parenchyma cells, sieve tubes, and companion cells or some medullary ray cells. The sieve tubes and companion cells are inconspicuous, and the former can occasionally be distinguished by the character of their transverse walls. The walls of the parenchyma cells are sometimes slightly lignified and pitted. They are usually filled with minute starch grains or brown substance. Sometimes the calcium oxalate in the raphides or clinorhombic forms are observed. They measure from 0.005 to 0.010 millimeter in length.

In the examination of the macerated sections by Schultze's process the most conspicuous elements observed are the secretion cells, the stone cells, and the sclerenchyma fibers. The secretion cells are numerous and they appear either axially elongated, elliptic, or ovoid in shape. They are from 0.025 to 0.09 millimeter long and from 0.012 to 0.03 millimeter wide (Plate 4, fig. 19, *a*). They contain either droplets of yellowish oil, or a brownish resinous substance, or are empty. The starch grains and other tissues are partially destroyed or deformed. Occasionally a fiber consisting of a row of stone cells is found as indicated in Plate 4, fig. 19, *b*, or a cluster of stone cells as shown in the same plate, fig. 19, *c*.

CINNAMOMUM CASSIA BLUME

According to Flückiger and Hambury (9) the various species of *Cinnamomum* occurring in the warm countries of Asia from India eastward, afford what is commonly called cassia lignea or

cassia bark, and the trees are extremely variable in foliage, inflorescence, and aromatic properties. But the true cassia bark has for a mother plant *Cinnamomum cassia* Blume, which is described by Bentley and Trimen (4) as follows:

A handsome tree of moderate size, with the younger branches somewhat tetragono-compressed; bark thick, smooth, pale, young twigs finely tomentose, buds smooth. Leaves evergreen, sub-opposite or alternate, 5–9 inches long, petiole about ½ inch, blade oval-oblong, tapering at base, acute or obtuse at apex, quite entire, very smooth, shining and green above, dull and glaucous with a very minute tomentum beneath, strongly 3-nerved, the nerves impressed above, very prominent beneath, the two lateral ones united with the midrib for a short distance from the base, and reaching the apex of the leaf, transverse connecting veins very numerous. Flowers small, stalked, without bracts, arranged in three and forming small cymose panicles at the end of long axillary and terminal peduncles; peduncles and pedicels finely tomentose or subglabrous. Perianth pubescent on both surfaces, rather smaller than in *C. zeylanicum*, and with the segment more obtuse. Androecium and pistil as in that species. Fruit broadly oblong-oval, apiculate, fleshy, shining, black, surrounded at the base by a cup formed by the persistent base of the perianth, which is narrowed below, transversely wrinkled, and has a thick, eroso-dentate margin. Seed filling the fruit, cotyledons large, plane-convex, radicle small, superior, no endosperm.

THE LEAVES

General external morphological features.—The above description of the leaf agrees well with the external morphological features of the average leaves of the two foreign specimens in the herbarium of the Bureau of Science, particularly the leaves of the specimen from the "Herb. Mus. Paris," collected by M. Le Dr. Thorel in his expedition to Me-Kong, herbarium No. 3192. The other specimen available in the herbarium is from the herbarium of the Canton Christian College, of the Flora of South China with the herbarium No. 136, collected by Levine and Groff from Teng Woo Mountain, Kwong Tung Province, and identified by E. D. Merrill. Outlines of the average form of leaves from the two specimens are shown in text fig. 3, *a–c*.

Internal structure of the leaf.—The transverse section of the blade is also bifacial, and it has the general appearance of that of *Cinnamomum zeylanicum;* but it measures only about 0.140 millimeter in thickness, which is about one-half the thickness of the blade of Ceylon cinnamon (text fig. 3, *e*). The upper and the lower epidermis consist also of single layers of rectangular or quadrangular and highly cutinized cells with very thick cell walls and greatly reduced cavities. The stomata are similar in structure to those of Ceylon cinnamon (text fig. 3, *h*), and the

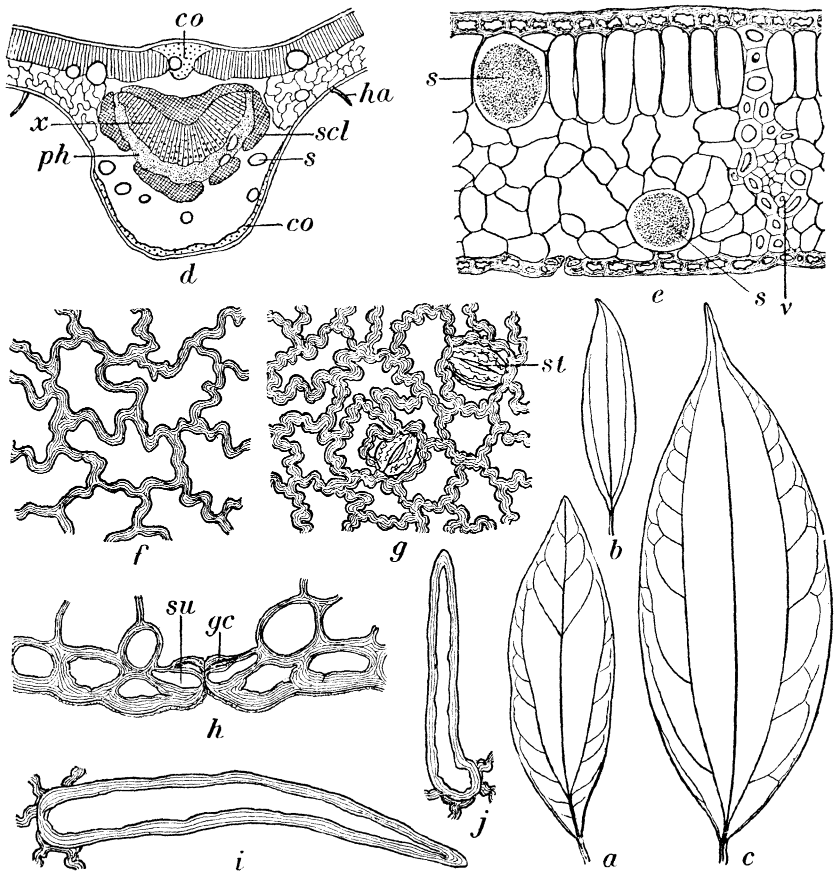

FIG. 3. *Cinnamomum cassia; a, b,* and *c,* three average leaves from the three Chinese specimens in the herbarium, × 0.5; *d,* a diagrammatic representation of a transverse section of the midrib (*co,* collenchyma; *scl,* sclerenchyma; *ph,* phloëm; *x,* xylem; *s.* secretion cells; *ha,* simple hair); *e,* a segment of the transverse section of the blade (*v,* vein; *s,* secretion cell), × 250; *f,* portion of the surface view of the upper epidermis, × 540; *g,* portion of the surface view of the lower epidermis (*st,* stoma), × 540; *h,* a portion of a transverse section of the lower spidermis showing a stoma (*gc,* guard cells; *su,* subsidiary cells), × 700; *i* and *j,* two simple hairs, × 540.

simple unicellular hairs are confined also in the lower epidermis. A single layer of palisade chlorenchyma cells occupies about one-third of the mesophyll, and the individual cell is about 0.05 millimeter long and 0.015 millimeter wide. The secretion cells are ovoid or spheroidal, and are found not only between the palisade cells but also in the lower part of the spongy chlorenchyma region. These secretion cells, like those of *Cinnamomum zeylanicum,* contain yellowish essential oil and rarely mucilage. They are from 0.04 to 0.05 millimeter long and from 0.04 to 0.045 millimeter in diameter. Secretion cells of rounded

form are frequently found in the spongy region, and they are usually smaller in size than those between the palisade cells. The spongy region is fairly well developed, and it consists of irregularly shaped spongy chlorenchyma cells, about 0.03 millimeter long and 0.015 millimeter wide, with large intercellular spaces. The transverse section of the veinlet shows a structure similar to that of the Ceylon cinnamon, but the veinlets of *C. cassia* are smaller and the thick-walled, slightly lignified cells extending from the conducting tissues to the epidermis are usually found in a single vertical row (text fig. 3, *e*).

The transverse section cut through the midrib is slightly convex above and very strongly convex below (text fig. 3, *d*). The upper and the lower epidermis are also composed of single layers of nearly quadrangular cells with greatly cutinized and thickened walls. Just below the upper epidermis there is a narrow group of collenchyma cells which are arranged in wedge shape and bounded at the lateral sides by the palisade cells extended to the upper part of the midrib. Occasionally, one or two secretion cells containing essential oils are found between the collenchyma cells. The collenchyma cells in the inner part of the lower epidermis consist of two or three rows of cells arranged from one side of the midrib to the other.

The meristele is crescent shaped. In the outer part, like that of the Ceylon cinnamon, it is surrounded by an interrupted band of thick-walled, slightly lignified sclerenchyma cells as shown in text fig. 3, *d*. The phloëm region, as usual, is composed of small cells with polygonal outline and confined in the lower part of the xylem region. The xylem region is composed of vessels and wood parenchyma arranged more or less in radial rows. The vessels measure from 0.015 to 0.025 millimeter in diameter. The upper lower part of the meristele is occupied by two groups of parenchyma cells which have small intercellular spaces and contain some starch grains. The endodermis is not conspicuous. The secretion cells, containing essential oil or sometimes mucilage, are usually found scattered in these two parenchyma regions, especially in the lower part and occasionally in the phloëm, mixed with the sieve tubes and companion cells.

Surface preparation.—The upper epidermal cells of *Cinnamomum cassia* in the surface view are also polygonal in outline, like those of *C. zeylanicum* with wavy outline, but they have very much thinner walls. They measure from 0.025 to 0.035 millimeter in their greatest diameter and from 0.01 to 0.02 millimeter in their least diameter. The thickness of their walls is

about 0.003 millimeter. Text fig. 3, *f*, shows the characteristic outline of the upper epidermal cells. The surface view of the lower epidermal cells reveals that they are also polygonal in outline, with strongly wavy walls and with numerous stomata with indistinct outline and some simple unicellular hairs (text fig. 3, *g*). The guard cells, like those of *C. zeylanicum*, are found in depressions, and their exact outline cannot be very well observed. The hairs measure from 0.06 to 0.12 millimeter in length, and they also possess thick walls (text fig. 3, *i* and *j*).

THE BARK

The dried bark or commercial bark.—The bark of *Cinnamomum cassia* Bl. is commonly known in the local market as Chinese cinnamon or "canela de China." It is obtained from the shoots of trees 5 to 6 years old and is often deprived more or less of the greater part of the corky portion. The bark with entire periderm occurs as simple quills not inserted one within another (Plate 5, fig. 20, *a–e*). The individual pieces are from 20 to 30 centimeters long, 10 to 30 millimeters wide, and 1 to 2 millimeters thick. The outer surface is grayish brown with whitish patches; it is uneven and rough, and has some rounded, slightly elevated lenticels and frequently some transversally elongated branch and leaf scars, as represented in the photograph on Plate 5, fig. 20, *c* and *d*.

The commercial cassia bark considered to be the best quality has a general resemblance to the Ceylon cinnamon. It is also usually prepared from shoots 5 to 6 years old and deprived of the greater part of the corky region. The quills are also simple and not inserted one within another. They measure much shorter, but slightly thicker, and are much less straight, even, and uniform than Ceylon cinnamon. The outer surface is rough, darker brown, often with grayish patches due to the imperfect removal of the corky layer by the knife. The inner surface is dark brown, nearly smooth, and faintly striated. The fracture is short and somewhat uneven. The bark is aromatic and has a slightly astringent taste.

Microscopical structure.—The transverse section of the bark of Chinese cinnamon exhibits externally several rows of cork cells; the cells of the outer rows have thin slightly suberized walls and are loaded with a brown substance, while the cells of the inner rows have thick, pitted, nearly colorless walls and also contain a brown coloring matter (Plate 6, fig. 21). The

phellogen is not distinct. The cortical parenchyma, like that of the Ceylon cinnamon, is made up of eight to twelve layers of tangentially elongated or rounded parenchyma cells loaded with starch grains or starch grains mixed with some calcium crystals in raphide form. Small isolated groups of stone cells, with one side thickened and with pitted walls, are scattered in the cortical parenchyma. These stone cells contain either starch grains or a brown substance. The starch sheath is not conspicuous. The middle part of the section of the bark is composed of large, interrupted, sclerenchymatous stone cells with a more-conspicuous one-sided thickening and pitted cell walls. These stone cells, like those of the Ceylon cinnamon, are tangentially elongated or polygonal in outline and they contain minute starch grains, but their walls are thinner and their cavities are larger. They are from 0.04 to 0.12 millimeter long and from 0.02 to 0.06 millimeter wide. In the outer part of the sclerenchyma ring or mixed with the patches of the stone cells are groups of small, thick-walled cells with polygonal outline. These cells correspond to the primary bast fibers or pericyclic fibers. Plate 5, fig. 22, represents a segment of the sclerenchymatous ring illustrating the characters of the stone cells. The inner part of the stone-cell ring is occupied by six to eight layers of parenchyma cells with isolated or small groups of stone cells having thinner walls, and by some secretion cells containing essential oil or mucilage. The parenchyma cells contain minute starch grains, sometimes mixed with calcium oxalate, or sometimes with a large amount of calcium oxalate crystals in raphides only. Like the Ceylon cinnamon the medullary rays are either in a single row or are two rows of cells wide; but the walls of the medullary-ray cells of Chinese cinnamon usually are much thicker and pitted, and those towards the sclerenchyma region are loaded with large amounts of starch grains with some calcium oxalate crystals; while those towards the inner region of the liber contain calcium oxalate crystals in raphide forms. Plate 6, fig. 24, represents a cell drawn from the medullary ray cells towards the inner region of the liber. The calcium oxalate crystals are in raphide forms and measure about 0.028 millimeter in length, while the starch grains are rounded and measure from 0.025 to 0.045 millimeter in diameter.

The bast region has also a general resemblance to that of Ceylon cinnamon, but the bast fibers are much larger in diam-

eter and more or less circular in outline (Plate 6, fig. 23). They measure about 0.03 millimeter in diameter and are usually found in groups of two or four cells arranged in radial rows. The secretion cells containing mucilage are more numerous and larger than those of *C. zeylanicum.* They measure from 0.04 to 0.06 millimeter in diameter. The phloëm parenchyma cells are either circular in outline or tangentially elongated. They are loaded with starch grains or calcium oxalate crystals or both, or sometimes with a brownish substance (Plate 7, fig. 26). The phloëm cells proper, that is the sieve tubes and companion cells, are mostly in a collapsed condition in which the individual cells cannot be distinguished.

The radial section of the bark of Chinese cassia as a whole is very similar to that of Ceylon cinnamon, but much coarser in structure (Plate 6, fig. 25). The secretion cells are prominently larger—about 0.12 millimeter long and 0.05 millimeter wide. The pith rays are comparatively wider and composed usually of about nine rows of cells.

The most conspicuous elements observed in the microscopical examination of the macerated bark are the bast fibers and stone cells. The bast fibers are irregular in outline, shape, length, and diameter. They measure from 0.08 to 0.20 millimeter in length and from 0.005 to 0.015 millimeter in diameter with blunt, pointed, rounded, or truncate ends. Sometimes they are constricted in a certain part and somewhat swollen in another part, as shown on Plate 7, fig. 27, *c*. Occasionally, a transverse view of the medullary rays is observed as indicated on Plate 7, fig. 27, *a* and *b*. The stone cells, as in the transverse and longitudinal sections, are very irregular in shape. They exhibit one-sided thickening, although when the thicker part of the walls of these stone cells happens to be placed towards the upper side and the thinner part towards the lower side as shown on Plate 7, fig. 27, *e*, their walls appear uniformly thickened. The secretion cells are also somewhat prominent because of their size and content. Most of them are more or less ovoid in shape, often isolated but sometimes in groups of two. They are usually empty but in some cases are filled with droplets of yellowish oil (Plate 7, fig. 27, *f*). Few cork cells are observed scattered and intermingled with the stone cells and parenchyma cells; sometimes they have slightly thickened walls (Plate 7, fig. 27, *d*).

CINNAMOMUM MINDANAENSE ELMER

This evergreen tree is found growing extensively in thickets and forests at low and medium altitudes in Mindanao, especially in Surigao and Davao Provinces, where various botanical specimens were collected and from which the original description by Elmer(7) was prepared (Plate 8, figs. 28–31). The species has a close resemblance to *Cinnamomum burmanni* in general appearance. On account of this similarity its specific status is often questioned, and it is sometimes considered to be a variety of *C. burmanni,* which is supposed to have been introduced in the Philippines. Elmer(7) described it as a distinct species, as follows:

A medium sized tree; stem 10 m. high and 3 dm. thick, straight, terete, usually branched from below the middle; main branches ascending, freely branched and ultimately numerous rebranched, forming a dense elongated crown; twigs lax, slender, somewhat drooping, smooth and green, dark brown or blackish in the dry state; wood moderately hard, whitish throughout, odorless and tasteless; bark very smooth throughout, finely mottled with grayish brown and whitish blotches on the epidermis, otherwise cinnamon brown and similar in taste, readily separating into small slabs, nearly 1.5 cm. thick on the stem, only one-half as thick on the larger branches. Leaves opposite or subopposite, scattered along the twigs, the average blades 1 dm. long by 3 cm. wide across the middle or a trifle below it, entire, glabrous, ascendingly spreading, rather numerous, recurved especially toward the acute or acuminate apices, curvingly conduplicate on the upper dark green and semilucid surface, subglaucous beneath, base obtuse or acute and frequently inequilateral, oblong or the smaller ones lanceolate; petiole less than 1 cm. long, frequently only one-half as long, brown in the dry state, glabrous; bud bracts cinerous, 4 mm. long; midrib straight clear into the apex, its basal lateral pair arising some distance above the base and extending two-thirds the length of the blade, the 1 to 3 secondary lateral pairs arising from above the middle and very obscure. Inflorescence divaricate or ascending, averaging 15 cm. long or less, all the stalks smooth and yellowish green, terminal or from the uppermost leaf axils, sparingly branched from beneath the middle; secondary branches only occasionally rebranched, slender, divaricate, bearing at their ends 1 to 2 or even 3 flowers; pedicels similar, 6 to 9 mm. long; perianth in anthesis 6 mm. long, glabrous, the basal one-third united and turbinate; its segments 6 equal, 3.5 mm. long, 2.75 mm. wide, oblong, roundly obtuse at apex, very finely ciliate at least along the margins, veinly in the middle region, glandularly dotted; stamens 12, without glands or even without staminodes, in 2 series opposite the perianth segments; filaments of the outer 6 nearly 2 mm. long, flattened, finely ciliate at the base, those of the inner series less than one half as long; anthers of the outer ones introse, 4-celled, the lower cells larger, lids hanging from the upper ends, 1.25 mm. long, basifixed, truncate at both ends; the inner 6 anthers ovate in outline, only the lower 2 cells present and lateral, hardly extrose; ovary glabrous, 1. 5 mm long, ellipsoid; style 1 mm. longer, also glabrous, bearing

a much enlarged pulverulent stigma; fruits ovately ellipsoid, lucid green with minute whitish spots, when mature shining steel blue and truly ellipsoid, 1.25 cm. long, 7.5 mm. across the middle.

THE LEAVES

General external morphological characters.—The leaves of *Cinnamomum mindanaense* exhibit only slight variation in size and shape. On text fig. 4, *a–d,* four of the outlines of the average forms of leaves of the specimens collected from Misamis, Mount Apo, Davao, Surigao, and Zamboanga are represented.

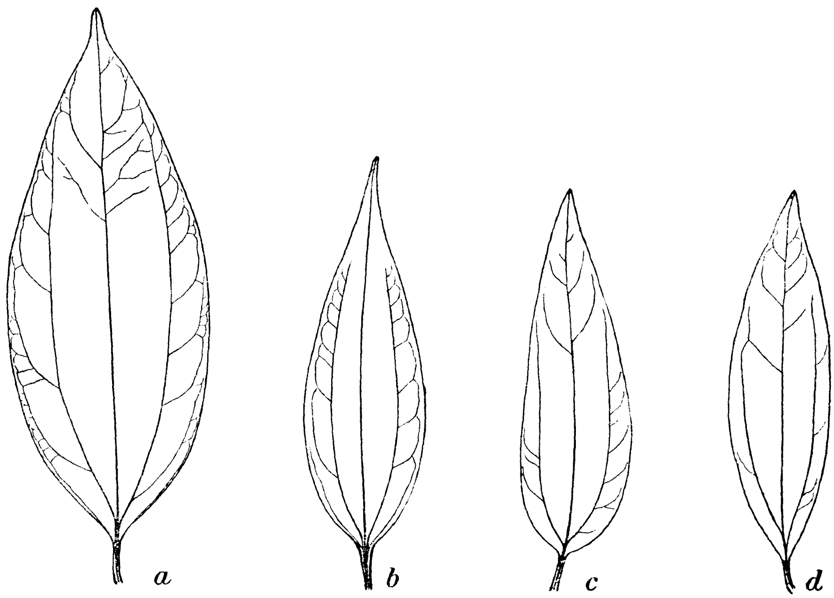

FIG. 4. *Cinnamomum mindanaense,* average leaves from the different specimens; *a,* a leaf from the specimen from Zamboanga; *b,* from Surigao; *c,* from Misamis; *d,* from a cotype specimen from Mount Apo, Todaya, Davao. × 0.5.

The full-grown leaves are usually from 6 to 15 centimeters long and from 2.5 to 6 centimeters wide at the widest part. They vary from lanceolate to oblong-ovate in outline, petiolate, trinerved or triplinerved, glabrous, slightly coriaceous, dark green and somewhat shining on the upper surface, subglaucous beneath, with entire margin. The base is obtuse or acute and sometimes inequilateral, and the apex acute or acuminate. The petioles are from 8 to 12 millimeters long. The two basal lateral veins, like those of *C. zeylanicum,* may arise at the base and run parallel to the upper part of the midrib up to 6 to 10 millimeters above, or they may apparently arise at about 10 millimeters above the base and pass archwise towards the apex but without reaching it. The transverse veinlets in most cases are not distinct.

Internal structure of the leaf.—A transverse section of the lamina of the leaf of *Cinnamomum mindanaense* has more or less the same general appearance as that of *C. zeylanicum* and *C. cassia* (text fig. 5, *b*). It is, however, thinner than that of *C. zeylanicum*, but slightly thicker than the blade of *C. cassia*. It measures about 0.152 millimeter in thickness. The upper epidermis and lower epidermis consist also of a single layer of cells with thick and highly cutinized cell walls. The stomata closely resembles those of the other two described species, but the guard cells are smaller and mostly in a collapsed condition. They are only found in the lower surface. The simple unicellular hairs are rarely found in the lower surface of the transverse sections. In text fig. 5, *c*, a portion of the lower epidermis is represented showing the detail structure of a stoma, together with the guard cells and subsidiary cells. The palisade region is composed of palisade chlorenchyma cells measuring about 0.05 millimeter in length by 0.011 millimeter in width. The secretion cells are frequently found between the palisade cells. They are either rounded, elliptical, or ovoid; about 0.06 millimeter in vertical diameter and 0.045 millimeter in horizontal diameter, and they are usually filled with yellowish essential oil or are empty. The spongy chlorenchyma region, like that of *C. cassia*, is fairly well developed and made up of irregularly shaped cells with intercellular spaces. Occasionally the secretion cells are found in this region. The veinlets, like the veinlets of *C. zeylanicum* and *C. cassia*, are found at intervals and are also vertically transcurrent by means of thick-walled and polygonal sclerenchyma cells which are arranged in two or more rows.

The midrib in the transverse section is slightly convex above and strongly convex below (text fig. 5, *a*). The upper epidermal cells and the lower ones, like those of the above species, are quadrangular or nearly rounded. Their outer walls are conspicuously thickened and highly cutinized. The cuticle measures about 0.002 millimeter in thickness. The collenchyma region located below the upper epidermis is sometimes more or less fan-shaped in outline and its lower part extends to the sclerenchyma ring of the meristele. It is composed of about seven layers of cells with nearly uniformly thickened walls. The collenchyma cells at the lateral part of the group are arranged in two or three rows and stretched along the inner side of

the epidermis towards the palisade regions. The collenchyma cells in the lower part consist of two or three layers arranged along the inner side of the lower epidermis from one side of the midrib to the other, but without reaching the spongy regions.

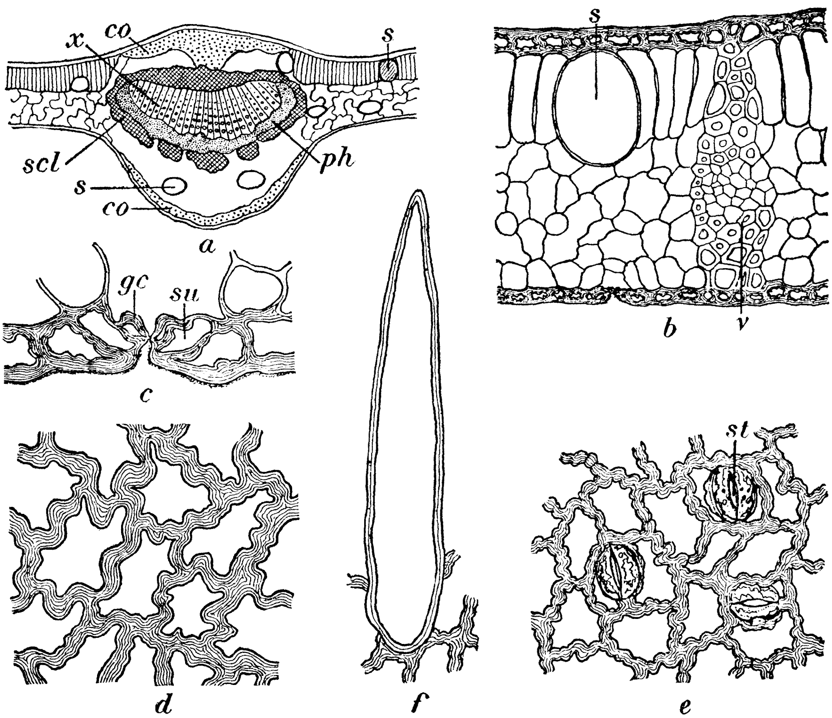

FIG. 5. *Cinnamomum mindanaense; a,* a diagrammatic sketch of a transverse section of the midrib (*co,* collenchyma; *scl,* sclerenchyma; *ph,* phloëm; *x,* xylem; *s,* secretion cell); *b,* a segment of a transverse of the blade (*v,* vein; *s,* secretion cell), × 250; *c,* a portion of a transverse section of the lower epidermis showing a stoma (*gc,* guard cells; *sc,* subsidiary cells), × 700; *d,* a segment of the surface view of the upper epidermis, × 540; *e,* a segment of the surface view of the lower epidermis (*st,* stomata), × 540; *f,* a single hair, × 540.

The meristele is nearly crescent in shape and not conspicuously limited from the cortical parenchyma by an endodermis. The outer region is surrounded by three or four irregular layers of sclerenchyma cells with slight interruptions in the lower part. The phloëm cells are very small and are found only in the lower part of the xylem. The vessels are arranged in radial rows and measure about 0.015 millimeter in diameter. The cortical parenchyma cells are very similar to those of *C. zeylanicum* and *C. cassia.* They also exhibit small intercellular spaces and con-

tain some starch grains or a few crystals of calcium oxalate. Some secretion cells containing essential oil or mucilage are frequently found between the parenchyma cells.

Surface preparation.—The surface view of the upper epidermis is very similar to that of *C. zeylanicum* and of *C. cassia,* except that the epidermal cells have thinner walls and are less wavy than the former, but thicker and more wavy than the latter (text fig. 5, *d*). The epidermal cells measure about 0.03 millimeter in their longest diameter by about 0.02 millimeter in their shortest diameter, and their walls are about 0.004 millimeter thick. The lower epidermal cells, as usual, are smaller than the upper ones, and their walls are thinner and more wavy in outline (text fig. 5, *e*). They measure about 0.02 millimeter in their longest diameter and 0.015 millimeter in their shortest diameter. The stomata are also confined to the lower epidermis and they are found below the level of the ordinary epidermal cells. Their outlines are not very distinct, and they are very much smaller than the stomata of the two species described above. The simple unicellular hairs are not numerous and they have thinner walls, but they are larger and longer than those of *C. zeylanicum* and *C. cassia.* They are about 0.12 millimeter long and 0.018 millimeter wide (text fig. 5, *f*).

THE BARK

The external features of the fresh bark of *Cinnamomum mindanaense* are given by Elmer(7) in his description quoted above for the plant.

The commercial bark.—The dried bark of *C. mindanaense* occurs in the market with or deprived of the greater part of the corky portion. It appears very similar to the commercial bark derived from *C. cassia.* In fact, for some time, it has been suspected that the dried bark of *C. mindanaense* is being sold in this country by retail stores as "Chinese cinnamon," the bark derived from *C. cassia.* The commercial bark from *C. mindanaense,* however, occurs either in simple or in a few overlapping quilled pieces measuring from 50 centimeters to 1 meter in length and 6 to 8 centimeters in width. These pieces of bark are probably prepared from either the main stem or branches from 6 to 10 years old, deprived of their suberous coat and frequently inserted one within another. Each side of the quill is made to curl inward like that of *C. zeylanicum* to form a channel with incurving sides, which makes the entire structure a somewhat flattened cylinder about 4 to 5 centimeters in dia-

meter (Plate 9, fig. 34, *a–f*). The thickness of the individual quill varies from 1 to 3 millimeters. The outer surface may be rough or smooth, but it is less smooth than the outer surface of the cassia bark and usually darker brown or similar in color; often with transverse markings and large branch scars. Longitudinal striations like those found on the outer surface of *C. zeylanicum* are not observed. Sometimes patches or portions of the corky region are found on the outer surface. This is perhaps due to carelessness in the peeling of the suberous coat. The inner surface is dark brown and somewhat longitudinally striated. The fracture is short and brittle, and the fracture surface is smoother or more even than that of cassia bark. It is aromatic like cinnamon bark, and the taste is also astringent.

The dried bark with suberous coat is considered of inferior quality. It also occurs either as simple or few overlapping quills (Plate 9, fig. 34, *f*). The outer surface is grayish brown with grayish-white patches of lichens, rough with longitudinal shallow fissures, and prominent tangentially elongated stem scars. The inner surface is also dark brown.

Microscopical structure.—The structure of the periderm of a transverse section of the bark of *Cinnamomum mindanaense* is very similar to that of *C. cassia*. The cork cells are also slightly suberized and some have thick walls, which usually contain a brown substance. The cortical parenchyma is made up of several layers of slightly thick-walled, pitted and tangentially elongated cells which sometimes contain a brown substance. A few secretion cells are usually found between the parenchyma cells. These, like those observed in the other species described, contain yellowish essential oil and sometimes mucilage. Some stone cells, in small isolated groups, are intermingled with the parenchyma cells. These stone cells have thinner walls than those found in the middle region of the section, with one side of their walls thicker than the other and pitted. The pericyclic region consists of interrupted, large, polygonal and tangentially elongated, or irregularly shaped stone cells with a distinct one-sided thickening and pitted cell walls like those of *C. cassia* (Plate 10, fig. 35). They measure 0.04 to 0.12 millimeter in length by 0.02 to 4 millimeters in width. Unlike those of the other species described above, they are not usually loaded with starch grains except some of those found towards the bast region. The small groups of primary pericyclic fibers in the outer part of the stone-cell ring are not usually observed. This ex-

plains why the outer surface of the peeled bark does not show the longitudinal striation as does the bark of *C. zeylanicum.* The inner part of the stone-cell ring consists of tangentially elongated parenchyma cells with slightly thickened and pitted walls, and of groups of stone cells. Intermingled with the parenchyma and stone cells there are secretion cells containing mucilage or essential oil, which are also tangentially elongated. They measure about 0.08 millimeter in length and 0.04 millimeter in width. The middle region is composed of radiating groups of sclerenchyma cells mixed with a few bast fibers (Plate 10, fig. 36). These groups of sclerenchyma cells and bast fibers are separated either by tangentially elongated parenchyma cells, or by somewhat tangentially elongated medullary-ray cells two or three cells wide. The sclerenchyma cells and bast fibers have polygonal outlines and sometimes are tangentially elongated. Some of them are filled with starch grains or with a few prismatic crystals of calcium oxalate.

The bast region occupies about three-fourths of the thickness of the bark. It is characterized by the absence of the bast fibers as indicated on Plate 10, fig. 37, and by the presence of the numerous secretion cells, most of which contain mucilage and some essential oil. The phloëm cells are in groups, interrupted by the phloëm parenchyma and secretion cells and traversed by the medullary rays. They are nearly collapsed and have wavy outlines. The phloëm parenchyma cells have rounded or polygonal outlines sometimes tangentially elongated, while the secretion cells are usually rounded and empty. The medullary rays are one to three cells wide with slightly thickened and pitted walls. They usually contain prismatic calcium oxalate crystals, and those towards the periphery contain starch grains.

In the radial section the cortical and pericyclic parenchyma, the stone cells, and the secretion cells appear somewhat rounded or polygonal in outline, as shown on Plate 10, fig. 38. The sclerenchyma cells mixed with the bast fibers, on the other hand, appear slightly elongated. They have thick and pitted cell walls and their two ends are not pointed, while those of the bast fibers are pointed, as illustrated on Plate 11, fig. 40. On the same plate, fig. 41 is a portion of the radial section cut through the phloëm region. It is characterized by the fifteen rows of medullary cells filled with calcium oxalate crystals, and by the axially elongated secretion cells measuring from 0.06 to 0.25 millimeter

in length and 0.025 to 0.03 millimeter in width. The sieve tubes are quite evident by their transverse walls and content.

The powder.—The powder is yellowish brown to dark brown and has a strong aromatic odor very similar to that of *Cinnamomum zeylanicum*. Under the microscope the powder of *C. mindanaense* exhibits a great assemblage of the various kinds of tissues observed in the different sections described above (Plate 11, fig. 42, *a–h*). The stone cells appear very numerous and diversified in shape. They are observed singly or in groups, irregular, colorless or containing a reddish-brown granular substance, with uniformly thickened walls or one side thinner than the other. The bast fibers are quite prominent and are either fragmentary or entire, with thick or thin, slightly lignified walls and are spindle shaped. They are from 0.06 to 0.25 millimeter long and 0.005 to 0.01 millimeter wide. The starch grains may be simple or compound, rounded or polygonal, and are about 0.006 millimeter in diameter. The secretion cells are not conspicuous and they are usually found in the fragmentary form, but sometimes are observed entire, as represented on Plate 11, fig. 42, *h*. They appear like ordinary parenchyma cells, except that when treated with Soudan red in glycerin their walls become somewhat red. The medullary-ray cells are often identified in the larger fragments. They are characterized by their content, consisting of either numerous starch grains or calcium oxalate crystals. They may be in radial or tangential view. The sieve tubes and companion cells cannot be easily distinguished. The cork cells are occasionally observed, while the parenchymatous cells, in fragments or entire, singly or in groups, are very conspicuous.

Similar types of tissues are observed in the macerated section by Schultze's process; namely, the stone cells, bast fibers, parenchyma cells, etc.; but in this preparation the secretion cells are very conspicuous. They appear in large numbers, with ovoid or greatly elongated cells measuring .0045 to 0.17 millimeter in length and 0.02 to 0.03 millimeter in diameter (Plate 11, fig. 42, *i*). They usually contain droplets of yellowish oil or a somewhat yellowish white granular substance, or in some cases are empty.

CINNAMOMUM MERCADOI VIDAL

This large endemic tree is widely distributed in forests at low and medium altitudes from Babuyan Islands and northern

Luzon to Mindanao (Plate 12, figs. 43–51). It is commonly known as *kalingag* and, like the other species described above, is variable in height and in the shape, size, and texture of the leaves. This is especially evident among the plants growing at higher altitudes. It was originally described by S. Vidal (22) as follows:

Arbor ramulis striatis, radicis cortice subcamphorata, ramorum cortice fere inodora. Petioli fusci, slutaceo-rugosi, complanati, ad 1 cm. longi. Folia e basi cuneata, oblonga vel lanceolato-oblonga, apice longe obtuso-acuminata, longa, 7-12 cm. lata 2-4 cm., coriacea, margine increassato-revoluta, supra nitida subtus opaca, glabra, triplinervia praeter nerves basilares tenuissimos interdum praesentes, obsolete transverse venose vel avenia; nervis-lateralibus usque apicem fere attingentibus, usque ⅔ supra prominulis, apice evanescentibus. Paniculae foliis longiorae; pedunculis striatis, sub-angulatis; floribus mediocribus, ad 5 mm. longis, pedicellatis, perianthio cano-pubescente, profunde lobato, lobis sub-rotundatis, Bacca perianthio accrescente, striato, usque medium cincta; oblonga, interdum leviter apiculata, circ. 15 mm. longa.

Elmer (8) gives the following additional field information:

Field note:—Tree 50 feet high, with a 2 feet thick bole; wood soft, white and with yellowish streaks, with a strong green cinnamon odor, light, tasteless; bark comparatively thick, gray, rigid; young twigs green; leaves chartaceous, darker green on the upper curvingly conduplicate side; inflorescence terminal and subterminal, ascending or erect, yellowish or pale green; flowers slightly odorous, of the same color as the stalks except the deeper yellow anthers. "Caningag" is the Bagobo name. As soon as the tree was cut a sweet aromatic odor was detected and soon afterwards the woods in that vicinity were filled with it.

THE LEAVES

General external morphological characters.—The full-grown leaves vary according to the altitude at which the plants grow; for instance, those collected from an altitude between 5,000 and 8,000 feet measure from 5 to 10 centimeters in length by 2 to 5 centimeters in width, while in material collected at low and medium altitudes the leaves measure from 10 to 18 centimeters in length by 5 to 8 centimeters in width (text fig. 6, *a–h*). They vary also in form, from lanceolate to oblong-ovate, petiolate, trinerved, or triplinerved coriaceous, glabrous, dark green and shining on the upper surface. The lower surface is lighter green and may be glabrous or slightly pubescent. The margin is entire and slightly deflexed downward or revolute. The base is obtuse or acute and the apex acute or acuminate. The petioles are from 7 to 18 millimeters long, somewhat cylindrical,

and have shallow grooves on the upper part. The two primary lateral veins usually arise directly from the base, or sometimes at a distance of about 1 centimeter above the base, and pass arch-wise towards and near the apex, but as in *C. zeylanicum* without reaching it. The transverse veinlets, except the lateral ones, are usually inconspicuous and in a very few cases are distinct and reticulately arranged.

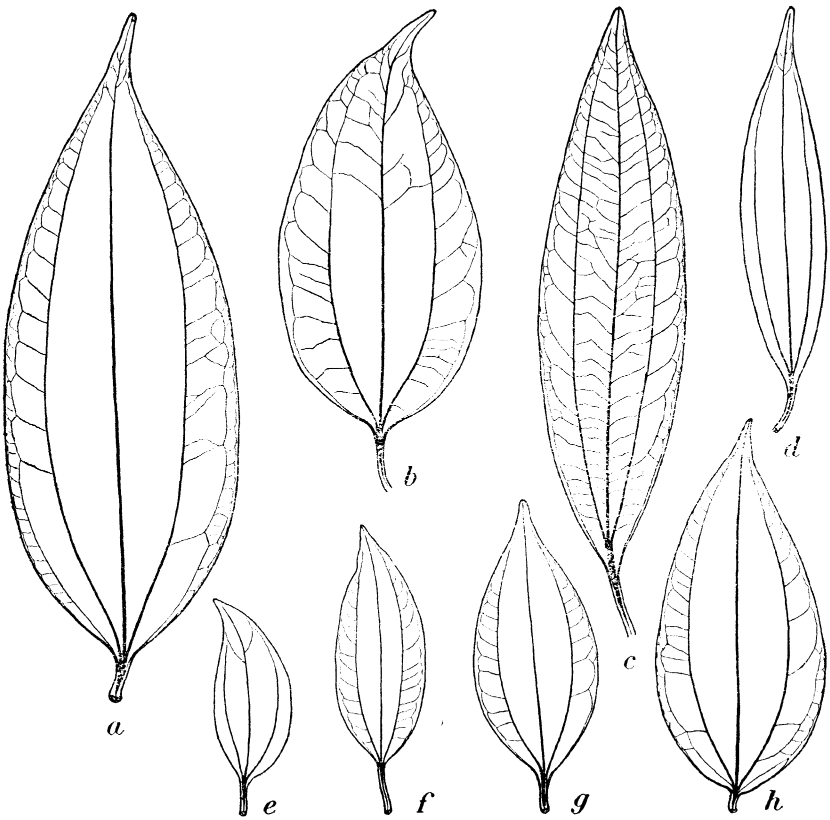

FIG. 6. *Cinnamomum mercadoi*, average leaves from specimens from various parts of Luzon; *a* and *d*, from Rizal; *b*, from Laguna; *c*, from Isabela; *e*, from Bontoc; *f*, from Benguet; *g*, from Mount Umingan; *h*, from Mount Bulilao, Capiz. × 0.5.

Internal structure of the leaf.—The transverse section of the blade of a full-grown leaf is also bifacial, measuring from 0.16 to 0.44 millimeter in thickness (text fig. 7, *b*, *c*, and *d*). The upper epidermis as well as the lower epidermis is also composed of a single layer of cells. The upper epidermal cells, like the corresponding epidermal cells of the other species described, are

more or less rectangular in outline with very thick and highly cutinized cell walls, but thinner than those of *C. zeylanicum*, and measure about 0.015 millimeter in thickness. The lower epidermal cells, however, at least in some of the specimens examined, differ from those of the other specimens in that they are sometimes papillous in character. This is true of the lower epidermal cells of the leaves of herbarium specimens *20233* and *46783*, as shown in text fig. 7, *d* and *e*. On the same text figure, *b*, a cross-section of the blade from a full-grown leaf taken from the cotype specimen *2459*, shows the normal type of lower epidermal cells. On account of this variation it is questionable or, rather, interesting to know whether this papillous character is inherent to the plant or whether these specimens having papillous epidermal cells belong to another species. An enlarged portion of the cross-section of the lower epidermis with normal cells and cut through a stoma is represented on text fig. 7, *e*, while a corresponding section from a cross-section of the lower epidermis with papillous cells is shown as fig. 7, *f*. The simple unicellular hairs are seldom found on the leaf with normal epidermal cells, but they are found to be numerous in the specimens with the papillous type of lower epidermis. The hairs and the stomata, as in the other species described above, are confined to the lower surface only. The stomata are also sunken and show the same characteristics and structure as those of *C. zeylanicum*. The guard cells are depressed and overarched by subsidiary cells, which are arranged parallel to the pore. The palisade cells measure about 0.05 millimeter in length and about 0.012 millimeter in diameter. They consist mostly of a single layer, but sometimes a secondary layer, consisting more or less of loosely arranged short palisade cells, is observed. They measure about 0.03 millimeter in length. The secretion cells are usually located below the upper palisade layer. They are either rounded polygonal or somewhat ovoid in outline. They contain frequently yellowish green essential oil, and they measure from 0.05 to 0.06 millimeter in their vertical diameter and from 0.03 to 0.05 millimeter in their horizontal diameter (text fig. 7, *b*, *c*, and *d*). The spongy region occupies a greater portion of the mesophyll, with regular-sized intercellular spaces, and occasionally one or two secretion cells are found in the lower region. The veinlets occur also at intervals along the section, most of which are cut obliquely. The transverse sections of the veinlets appear very similar to those of the other species. They are

also vertically transcurrent on both sides by means of polygonal sclerenchyma cells arranged in a single vertical row.

A transverse section cut through the midrib is convex above and broadly convex below (text fig. 7, *a*). It is quite similar to that of *C. zeylanicum* except that it is smaller. The upper and lower epidermis consist of single layers of nearly quadrangular,

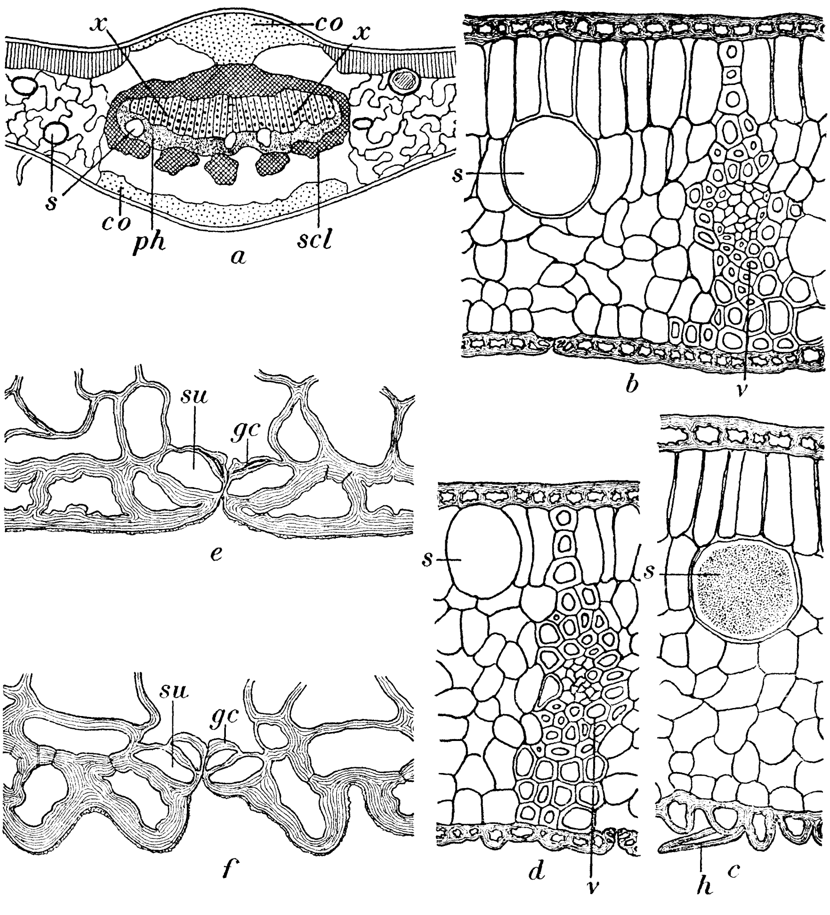

FIG. 7. *Cinnamomum mercadoi; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade from a cotype specimen, *2459* (*v*, vein; *s*, secretion cell), × 250; *c*, a segment of a transverse section of the blade of specimen *4678*, showing papillous type of lower epidermal cell (*h*, hair), × 250; *d*, a segment of a transverse section of the blade from specimen *20933*, × 250; *e*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cell; *su*, subsidiary cell), × 700; *f*, a portion of a transverse section of the lower epidermis of specimen *46783*, showing also a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700.

highly cutinized cells with greatly reduced cavities. The upper collenchyma region is also fan-shaped like that of the Ceylon cinnamon while the lower portion is extended to the sclerenchyma ring, while the lateral sides extend to the palisade regions. The lower collenchyma region extending along the inner side of the lower epidermis consists of two or three layers of cell. The parenchyma cells around the conducting tissues have thin walls, are nearly round in outline, and have very small intercellular spaces. Sometimes they are filled with starch grains and frequently two or more secretion cells are found between them. The meristele is not sharply limited from the parenchyma cells by endodermis. In the outer part around the conducting tissue, there are two or three rows of thick-walled sclerenchymatous cells with three or four slight interruptions in the lower part. The conducting tissues are grouped more or less in a lenticular form with the phloëm region confined to the lower side only. Very often between the phloëm cells there are secretion cells containing either essential oil or mucilage. The water-conducting cells are arranged in radial rows and their average diameter is about 0.018 millimeter.

Surface preparation.—The upper epidermal cells appear in the surface sections as polygons measuring about 0.035 millimeter in their longest diameter and about 0.025 millimeter in their shortest diameter (text fig. 8, *b*). They have very thick and highly cutinized and wavy walls about 0.008 millimeter in thickness. The walls of the upper epidermal cells of *C. mercadoi* are about as thick as those of *C. zeylanicum* or slightly thicker and are sometimes faintly striated. The lower epidermal cells are also polygonal in outline, and measure about 0.02 millimeter in length and about 0.01 millimeter in width (text fig. 8, *b*, *c*, and *d*). Their walls measure about 0.004 millimeter in thickness and are not as much convoluted as those of *C. zeylanicum* or *C. cassia*. The stomata are larger than those of *Cinnamomum zeylanicum*, *C. cassia*, or *C. mindanaense*. The guard cells are clearly visible with two distinct, large neighboring cells at the sides. The hairs are simple, unicellular, and have very thick walls. They vary in length from 0.1 to 0.3 millimeter and are about 0.015 millimeter wide (text fig. 8, *c* and *f*). These hairs are only found on the lower epidermis of the leaves that have the papillous type of epidermal cells. They may be straight or wavy in outline.

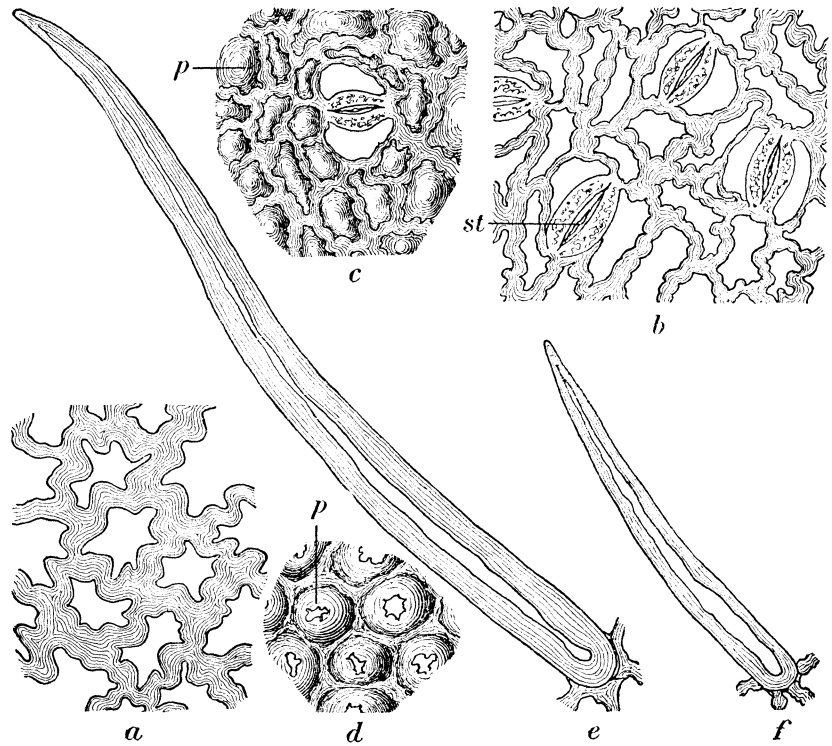

FIG. 8. *Cinnamomum mercadoi; a,* a portion of a surface view of the upper epidermis, × 540; *c,* a portion of a surface view of the lower epidermis (*st,* stoma), × 540; *c* and *d,* portion of the surface view of the lower epidermis of specimen *46783* (*p,* papilla), × 540; *e* and *f,* simple hairs, × 540.

THE BARK

The old bark.—The bark from a large trunk measures from 8 to 15 millimeters in thickness. The outer surface is dark brown and sometimes greenish brown with grayish patches of lichen or greenish shadings due to the presence of lower forms of algæ. It is uneven, rough, and sometimes scaly due to the irregular longitudinal and transversal fissures. The scales of the suberous coat are not easily separable. The middle part is also granular as in the other species and more or less fibrous. The fracture is somewhat tough, and the fracture surface is nearly even in the outer part but slightly splintery in the inner part.

The younger bark is much thinner and usually measures from 4 to 7 millimeters in thickness (Plate 13, fig. 52, *a–c*). The external part is also grayish brown or dark brown, with some

yellowish green patches of lichens or algæ. It may be smooth or rough with numerous elevated lenticels. These lenticels are sometimes observed arranged in groups. They may be rounded or axially elongated. The middle region of the bark is also slightly granular. The inner surface when fresh is creamy white and gradually becomes dark with longitudinal fine striations. The pieces of bark when dried appear flat or slightly quilled. The fracture is short, and the fracture surface is even towards the corky region and uneven toward the phloëm region. The odor is aromatic like that of sassafras, and the taste is slightly astringent and sweetish.

Occasionally the bark of *C. mercadoi* is sold in the market like that of *C. mindanaense* deprived of most of the suberous coat and cortical parenchyma. The bark is observed in simple quills nearly flat and about 4 millimeters in thickness and the pieces of bark are not arranged one within another. The outer surface is dark brown, smooth or rough, with a few patches of the periderm in some places. The inner surface is nearly smooth and also longitudinally striated. The structure of the transverse section of the bark of *C. mercadoi* has a general resemblance to that of *C. cassia,* both have a coarse structure, but the latter is distinguished from the former by the type of its calcium oxalate crystals, secretion and stone cells, and odor.

Microscopical structure.—The outer suberous coat consists of several layers of tangentially elongated and radial rows of closely fitted and slightly suberized cork cells. Intermingled between the thin-walled cork cells there are layers of short pitted stone cells with one-sided thickening, as indicated on Plate 14, fig. 53. The cortical parenchyma is composed of eight to fourteen layers of tangentially elongated parenchyma cells which contain usually minute and rounded starch grains. Occasionally, between these parenchyma cells there are some secretion cells containing essential oils or mucilage, like those of the other species above. Sometimes some minute calcium oxalate crystals, in raphides or clinorhombic forms, are found mixed with the starch grains in some parenchyma cells. Very often a few groups of thin-walled stone cells are scattered in the cortex. The starch sheath, as usual in the other species, is not conspicuous.

The middle region of the section of the bark of *C. mercadoi* has a great similarity to the structure of the middle part of *C. cassia,* except that the stone cells are larger (Plate 14, fig. 54). These stone cells are tangentially elongated and they

measure from 0.06 to 0.10 millimeter in length by 0.06 to 0.82 millimeter in width. They are observed in groups arranged in an interrupted ring around the bark. Sometimes, as in the middle part of the bark of *C. zeylanicum*, small groups of sclerenchyma cells are found in the outer part of the stone-cell ring or partly mixed with the stone cells. The inner portion of this region, as that of the other barks, consists of several layers of parenchyma cells, polygonal in outline, and filled with minute starch grains or calcium oxalate crystals or both (Plate 14, fig. 55). Scattered between the parenchyma cells there are also some stone cells with thinner walls. These stone cells have larger cavities and exhibit also a conspicuous one-sided thickening. Between the stone cells, or between the parenchyma cells, secretion cells containing either mucilage or essential oils are present. Like the innermost part of the middle region of *C. zeylanicum* the parenchyma cells are smaller and distinctly polygonal in outline, most of them are also filled with starch grains or calcium oxalate crystals or both (Plate 14, fig. 56). This part is traversed by medullary rays which are two cells wide. The medullary-ray cells are larger than the corresponding medullary-ray cells of the other species described above. They are radially elongated and loaded also like the parenchyma cells of *C. cassia* with starch grains and calcium oxalate crystals.

The bast region is characterized by the presence of a larger number of bast fibers and parenchyma cells, loaded with a brownish substance instead of starch grains like those of *C. cassia* (Plate 14, figs. 56–58). The bast fibers are larger than the corresponding bast fibers of *C. zeylanicum,* but almost the same size as those of *C. cassia.* They are tangentially elongated and usually radially or tangentially arranged. The phloëm cells are mostly collapsed into strands, the cell cavities of which are scarcely visible. The secretion cells towards the cambial region are conspicuous for they contain distinct droplets of yellowish essential oil and they are rather numerous. The mucilage-containing secretion cells, however, are fewer but larger than the oil-containing secretion cells. They are readily distinguished from the latter because they are usually empty. The bast region is traversed by medullary-ray cells which are two cells wide; these are either loaded with a brownish substance or calcium oxalate crystals in raphide or fusiform shape as represented on Plate 14, figs. 57 and 58.

The cortical parenchyma cells and the stone cells from the middle portion of the radial section, appear more or less polygonal in outline, while the parenchyma cells of the inner region exhibit slight axial elongation. The bast fibers are spindle shaped, greatly elongated, and found either singly or in groups as in the transverse section. On Plate 14, fig. 59, a radial section, cut through the bast region is indicated. The medullary rays are from eight to twelve cells wide. As in the transverse section of the medullary ray, the cells appear loaded with minute starch grains or calcium oxalate crystals in raphides or clinorhombic forms and sometimes those in the inner part are filled with a brownish substance only. The secretion cells are prominent in the longitudinal section. They are as a rule axially elongated, but those towards the outer region are somewhat rounded or nearly elliptical. They may or may not contain droplets of essential oil or mucilage and measure from 0.05 to 0.1 millimeter in length and about 0.05 millimeter in width. Occasionally they occur among the medullary-ray cells as illustrated on Plate 14, fig. 59. The phloëm cells are not conspicuous; as they are collapsed into strands, their structure is rather obscure. In some cases, however, because of their characteristic tranverse walls, they become recognizable. The calcium oxalate crystals in raphides are also found in the phloëm parenchyma. They measure about 0.012 millimeter in length and about 0.001 millimeter in their greatest diameter. On Plate 15, fig. 60, is a transverse section of parenchyma cell containing many calcium oxalate crystals in raphides form.

In the preparation from the material macerated by Schultze's process, as in the other species, the most prominent tissues observed are the bast fibers, measuring from 0.08 to 0.25 millimeter, isolated or in groups, straight or somewhat crooked with sometimes a slight reduction in diameter in the middle part (Plate 15, fig. 61, *a*); the stone cells, which exhibit a diversity of forms with larger or small cavities and with thick or thin pitted cell walls (Plate 15, fig. 61, *b*); the secretion cells, which vary from 0.02 to 0.10 millimeter in length and from 0.012 to 0.022 in width, appear either empty or filled with droplets of yellowish essential oil or with mucilage, as indicated on Plate 15, fig. 61, *g;* the cork cells and the slightly lignified parenchyma cells have thicker walls. The mucilage-secretion cells are often observed swelling up and becoming

irregularly shaped with droplets of essential oil (Plate 15, fig, 61, *c*).

CINNAMOMUM INERS REINWARDT

According to Flückiger and Hambury (9) *Cinnamomum iners* is another decidedly variable species occurring in continental India, Ceylon, Tavoy, Java, Sumatra, and other islands of the Indian Archipelago, and possibly, in the opinion of Thwaites, (20) it is a mere form of *C. zeylanicum.* Meissner, (15) however, states that *C. iners* can be well distinguished by its paler and thinner leaves, its nervation, and the character of its aroma (Plate 16, figs. 61–65).

In the Philippines this species has been reported as occurring in Mindoro, Palawan, Samar, Mindanao, Tawi-Tawi, and Rizal, Luzon. The dried bark is occasionally sold as cinnamon.

Cinnamomum iners is a small to large tree with usually gray, smooth bark and sometimes with horizontal, wavy annular thickening. The leaves are opposite, petiolate, glabrous, coriaceous, trinerved, shining above and glaucous below, and vary in outline from lanceolate to oblong or linear oblong-ovate and from 8 to 20 centimeters in length. The apex is acute or acuminate, and the base may be rounded, obtuse, or acute. The inflorescence is paniculate, long peduncled and silky pubescent; the flowers small, about 4 millimeters long, with persistent perianth lobes. The fruit is ovoid in shape, and about 1 centimeter long; the base of which is sunk in the perianth (Plate 16, figs. 62–66).

THE LEAVES

General external morphological features.—As indicated above and illustrated in text fig. 9, *a–h,* the full-grown leaves exhibit great diversity in size and form. They measure from 8 to 21 centimeters in length by 2.5 to 9 centimeters at the widest part. The largest leaf is that from Java measuring 21 centimeters in length by 8.5 centimeters at the widest part (text fig. 9, *a*); next is that from Camp Kithley, Lake Lanao, Mindanao, which is 20.5 centimeters long by 6.5 centimeters wide (text fig. 9, *b*); the smallest also came from Camp Kithley, Lake Lanao, and measures about 10 centimeters in length and 2.2 centimeters at the widest region (text fig. 9, *f*). The leaf is lanceolate or linear oblong to oblong-ovate, petiolate, coriaceous, trinerved, glabrous and shining above, and glaucous below with

entire margin. The base is rounded, obtuse or acute, sometimes inequilateral, and the apex acute or acuminate. The petiole is from 9 to 12 centimeters long and slightly like that of *C. zeylanicum.* The midrib runs straight clear into the apex, its basal lateral veins arise either directly or about 8 millimeters above the base and extend arch-wise towards the tip. In large leaves the midrib does not reach the tip. The secondary veins as in the other species are not distinct, except in a few cases and those at the lateral part of the two basal primary veins.

Internal structure of the leaf.—The transverse section of the blade of the leaf of *C. iners* has a great similarity to the trans-

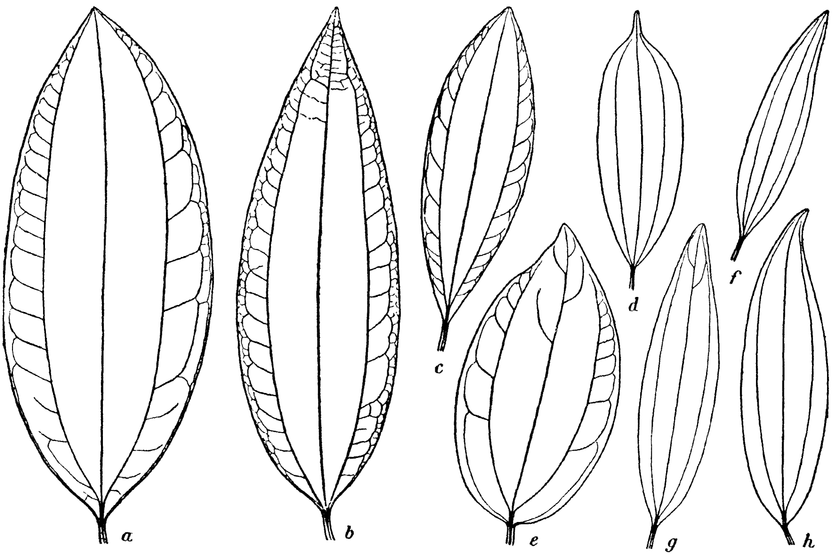

FIG. 9. *Cinnamomum iners*, average leaves from specimens from the Philippines and from abroad; *a*, from Java; *b*, from Camp Kithley, Lake Lanao, Mindanao; *c*, from Eil Simaloer bij., Sumatra; *d*, from Res. Palembang, Sumatra; *e* and *h*, from Catubig River, Samar; *g*, from herb. L. Pierre *6170*. × ⅓.

verse sections of those of the other species described above, particularly to that of *C. zeylanicum*, but it is much thinner than the latter and is more hairy (text fig. 10, *b*). The upper and the lower epidermis are made up of almost the same size and shape of cells as those of the Ceylon cinnamon, with thick walls and large cavities. The palisade chlorenchyma cells are wider and shorter, measuring about 0.06 millimeter in length and 0.015 millimeter in width. The secretion cells are not so numerous, and they are usually elongated, about 0.054 millimeter long and 0.029 millimeter wide, and contain yellowish essential oil. They are mostly found, as in *C. zeylanicum* and *C. min-*

danaense, in the palisade region. The spongy chlorenchyma is composed of large irregularly shaped cells with moderate sized intercellular spaces. They occupy about two-thirds of the thickness of the mesophyll. The veinlets are also found at intervals, and most of them are cut obliquely. They are strongly developed and are stretched out vertically from the upper to the lower epidermis by means of thick-walled polygonal sclerenchyma cells. At the lateral part they are usually bounded with one or two layers of thick-walled cells. In the upper region the xylem is connected with the upper epidermis by two or three vertical rows of thick-walled cells and the lower part, the phloëm region, is connected with the lower epidermis by means of three or four rows of cells which are also thick-walled like those of *C. zeylanicum.* The stomata are very similar to those of *C. zeylanicum* and the other described species and they are also confined to the lower surface. A portion of the lower epidermis, showing the structure of a stoma, is represented in text fig. 10, *c*. The hairs, as in the other species, are only found in the lower epidermis; and they are also simple, unicellular, and have thick walls. They are, however, much more numerous and longer than those of the other species of cinnamon. They measure from 0.1 to 0.2 millimeter in length and about 0.012 millimeter in diameter (text fig. 10, *f* and *g*).

The midrib in the transverse section is slightly convex above and somewhat strongly convex below, as indicated in text fig. 10, *a*. The upper and the lower epidermis consist of a single layer of nearly quadrangular thick-walled and highly cutinized cells. The sclerenchyma region in the upper part is rather poorly developed, although in some specimens is a fan-shaped structure like that of Ceylon cinnamon. It consists of two to three layers of cells extending from the palisade region of one side to the other. The collenchyma region in the lower part consists of a narrow strip of three or four layers of cells, and stretches out from one side of the midrib to the other, connecting the two spongy regions. The cortical parenchyma in the upper part of the meristele consists of a few layers of thin-walled parenchyma cells, while that of the lower part consists of about seven to eight layers of cells, some of which contain a brownish substance. Scattered in the cortical parenchyma there are some secretion cells of the same type as those of the other species, except that they are more numerous in this species. The meristele, as usual, is not limited by a distinct endodermal or starch sheath. The conducting tissue is more or

less plano-convex in outline, surrounded by an sclerenchyma ring with one or two narrow interruptions below. The sclerenchyma ring consists of three or four layers of thick-walled and slightly lignified cells. The vessels are arranged in radial rows and measure from 0.015 to 0.033 millimeter in diameter. The phloëm region as in the other species of cinnamon is confined to the lower part only. Some secretion cells are often found mixed with the sieve tubes.

Surface preparation.—The upper epidermal cells appear very similar to those of the *C. zeylanicum,* but they have slightly thinner walls which are about 0.005 millimeter thick with sometimes a very faint striation (text fig. 10, *d*). The epidermal cells are polygonal in outline with greatly undulated cell walls. They measure from 0.03 to 0.04 millimeter in their longest diameter and from 0.017 to 0.03 millimeter in their shortest diameter. The lower epidermal cells are similar to the epidermal cells of the other described species of cinnamon (text fig. 10, *e*). They are also polygonal in outline but with less-convoluted cell walls. They measure from 0.02 to 0.035 millimeter in their longest diameter and from 0.01 to 0.02 millimeter in their shortest diameter. The stomata are numerous and are found in depressions with indistinct outlines. The hairs are very numerous, simple, and unicellular. They measure from 0.011 to 0.180 millimeter in length. They may be straight, bent, or wavy in outline.

THE BARK

The only piece of bark of *Cinnamomum iners* available during the investigation was that taken from herbarium specimen *6264,* collected by the late Dr. C. F. Baker, from Impolutao, Bukidnon, Mindanao (Plate 19, figs. 75, *a* and *b*). This piece of dried, slightly quilled bark is about 9 centimeters long, 2.5 centimeters wide, and about 6 millimeters thick. The external part is light brown with grayish white and yellowish green patches of lichens or algæ. It is uneven and rough, with some slightly elevated, rounded or oblong lenticels and with transverse and longitudinal fissures on one side. The middle part is somewhat granular, reddish brown, and fibrous towards the inner part. The fracture is tough, and the fracture surface is uneven and slightly splintery in the inner region. The odor is aromatic, more or less like that of the sassafras and the taste is astringent, slightly pungent and aromatic.

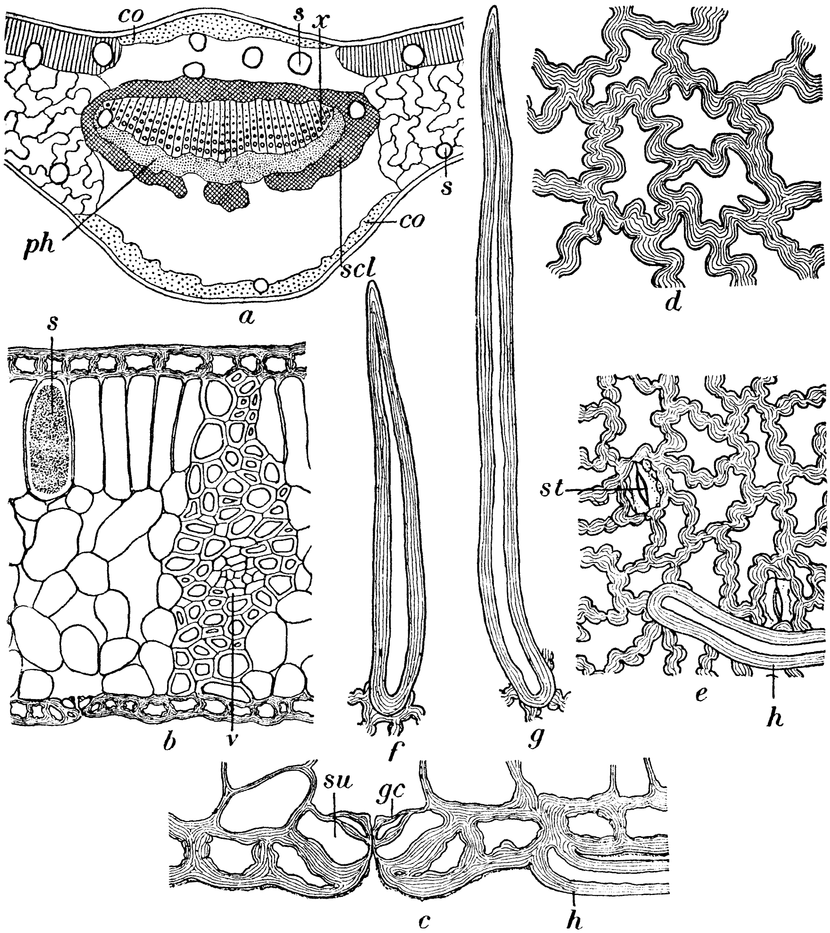

FIG. 10. *Cinnamomum iners; c*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells; *h*, hair), × 700; *d*, a portion of the surface view of the upper epidermis, × 540; *e*, a portion of the surface view of the lower epidermis (*st*, stomata; *h*, hair), × 540; *f* and *g*, simple hairs.

Microscopical structure.—The suberous coat in transverse section consists of ten to fourteen layers of tangentially elongated, closely fitted, and slightly suberized cork cells, all of which contain a reddish brown substance. Like the cork cells of cassia cinnamon, the outer layers have generally thin walls and the inner ones possess thick, pitted, and colorless walls, as represented on Plate 17, fig. 67. The phellogen is somewhat distinct.

The cortical parenchyma is composed of several layers of small polygonal and tangentially elongated cells, loaded with starch grains or a brownish substance and sometimes with calcium oxalate crystals (Plate 17, fig. 68). A few secretion cells that usually contain essential oil are scattered in this region. These secretion cells are similar to the ordinary parenchyma cells but are slightly larger and nearly rounded. The starch sheath is also inconspicuous.

The pericyclic region is similar to the pericyclic regions of *C. cassia* and *C. mercadoi*, but the stone cells are smaller and are arranged in comparatively smaller groups around the bark (Plate 17, fig. 68). The stone cells are separated by tangentially elongated parenchyma cells containing starch grains or some clinorhombic calcium oxalate crystals. The stone cells vary in shape and size. They are either rounded polygonal or tangentially elongated, and measure from 0.005 to 0.02 millimeter in diameter. Their walls are also pitted and slightly thickened at one side. Some of them contain starch grains and others a few calcium oxalate crystals. The inner part of the pericyclic is also composed of parenchyma cells, a few thick- or thin-walled stone cells, and some bast fibers (Plate 17, fig. 69). This region is traversed by medullary rays one or two cells wide. Between the parenchyma cells there are a few secretion cells which as in the other species of cinnamon contain either mucilage or essential oil.

The bast region occupies about one-half of the entire cross-section of the bark (Plate 17, fig. 70). It differs from those of the other species by (*a*) the numerous medullary rays, usually one cell wide; (*b*) the numerous bast fibers, isolated or in radial and tangential groups with distinct striation; and by (*c*) the small size of the secretion cells, which are very much fewer than the secretion cells of the other cinnamon species. The phloëm cells, as in the other barks, are all in a collapsed condition and their individual identity cannot be determined. The medullary-ray cells are loaded either with starch grains, calcium oxalate crystals, or a brownish substance. The bast fibers vary in outline from either rounded or quadrangular to rectangular with a very greatly reduced cavity. The secretion cells are found mostly empty and they measure from 0.036 to 0.045 millimeter in diameter. The medullary-ray cells are mostly one cell wide and radially elongated. Those towards the cambial region contain a brownish substance, and those towards the peripheral part

contain calcium crystals in clinorhombic forms. On Plate 17, fig. 72, a single medullary-ray cell filled with calcium oxalate crystals is represented. These crystals measure about 0.007 millimeter in length and about 0.002 millimeter in width.

The most characteristic part of the radial section is the middle part of the bast region. The bast fibers with tapering ends are found either singly or in groups of two or three cells. The secretion cells are axially elongated and found usually empty. The medullary ray consists of ten to twelve rows of cells, most of which contain calcium oxalate crystals and minute starch grains. A few stone cells are occasionally found mixed with the parenchyma cells in the outer part of the bast region. These cells, like those in the cross-section, exhibit slight one-sided thickening of their pitted walls. On Plate 17, fig. 71, a radial-section cut through near the outer part of the bast region is indicated.

The most conspicuous types of cells observed from the macerated preparation by Schultze's process are (*a*) the numerous bast fibers measuring from 0.1 to 0.2 millimeter in length and from 0.005 to 0.10 millimeter in diameter; (*b*) the very irregularly shaped stone cells with thick pitted cell walls and greatly reduced cavities (Plate 17, fig. 73, *a*), which measure from 0.015 to 0.06 millimeter in length and from 0.01 to 0.035 millimeter in width with slightly one-sided thickening (Plate 17, fig. 73, *b*) ; (*c*) the secretion cells, which are somewhat rounded or ovoid or elongated and measure from 0.02 to 0.05 millimeter in length and from 0.01 to 0.02 millimeter in diameter (Plate 17, fig. 73, *e*) ; (*d*) the cork cells, which are observed singly or in clusters, empty or filled with a brownish substance (Plate 17, fig. 73, *c*) ; (*e*) and the parenchyma cells with thickened, pitted, and slightly lignified cell walls (Plate 17, fig. 73, *d*).

CINNAMOMUM BURMANNI BLUME

This medium-sized tree is described in de Candolle's Prodromus (14) as follows:

> Folíís oppositisque chartaceis e basi acutá ovalibus oblongis lanceolatisve attenuato-subacuminatis triplinervíís ramulisque glabris concoloribus v. subtus glaucinis, supranitidis levibus v. utrinque minute subprominolo-reticulatis, nervis lateralibus apicem versus evanescentibus v. cum intermedíí ramis confluentibus, paniculis simplicibus brevibus pubescentibus v. glabriusculis, ramis 3-4 floris, pedicellis florem aequantibus. In Chiná el Japoniá, introd.? in Java, Sumatrá, ins. Philipp. etc.

There are three important varieties under this species; namely, *Cinnamomum burmanni* Blm. var. α *chinense, C. burmanni* Blm. var. β *angustifolium,* and *C. burmanni* Blm. var. γ *kiamis*. The variety indicated by Meissner(14) supposed to be introduced in the Philippine Islands is *C. burmanni* Blm. var. α *chinense.* It is distinguished, according to him, by the shape and the size of the leaves, which are oblong-ovate to ovate and are from 3 to 6 inches long and from 1 to 2 inches wide, and by the fact that the lateral veins originate 1 to 2 lines above the base. The plant has an aromatic and slightly cinnamonlike odor. On Plate 18, fig. 74, a habit sketch of a portion of the branch, drawn from a herbarium specimen collected in Java, is represented.

Cinnamomum burmanni Blume is extensively cultivated in Sumatra and Java. According to Wijers(23) it grows in all soils, but does best in those that are deep, permeable, and rich in humus and at heights between 2,000 and 3,000 feet. In the Philippines this plant has never been reported in the living condition except the one indicated above seen by Merrill(16) at Nagcarlang, nor is there a single dried Philippine specimen in the Bureau of Science herbarium to prove its existence.

THE LEAVES

General external morphological characters.—The full-grown leaves of *Cinnamomum burmanni,* as far as the available foreign specimens in the Bureau of Science herbarium are concerned, show great similarity in size, shape, and texture to those of *C. mindanaense.* They measure from 7 to 15 centimeters in length by 2 to 5 centimeters at the widest part. They vary slightly in outline from oblong ovate, ovate, or ovate lanceolate to lanceolate; they are petiolate, trinerved, glabrous, chartaceous, shining above, and glaucous below (text fig. 11, *a–d*). The base is obtuse, occasionally inequilateral, and the apex is from acute to acuminate with an entire margin. The petioles are from 5 to 9 millimeters long, nearly cylindrical, and have a slight groove on the upper part. Two basal lateral veins arise about 7 millimeters above the base and extend to two-thirds the length of the blade. Numerous secondary veins, arising from the outer lateral part of the two basal primary veins, extend towards the margin and join each other. Towards the upper part of the midrib there are frequently a few veins more or less of the first degree which anastomose with each other.

Internal structure of the leaf.—The blade in the transverse section is bifacial and very similar to the transverse sections

of the blades of the other species, particularly to that of *C. mindanaense*, but it is thinner than the latter which is about 0.126 millimeter thick (text fig. 12, *b*). The upper epidermis, as well as the lower one, consists of single layers of rectangular, thick-walled, and highly cutinized cells, measuring about 0.012 millimeter and 0.01 millimeter in thickness, respectively. The palisade chlorenchyma is somewhat different from that of *C. mindanaense* because the cells are shorter, with a general tendency to form two layers. The lower one consists usually of short and more loosely arranged palisade cells. The upper palisade cells measure about 0.03 millimeter in length and 0.008 millimeter in width, while the lower palisade cells are about 0.015 millimeter in length and 0.006 millimeter in width.

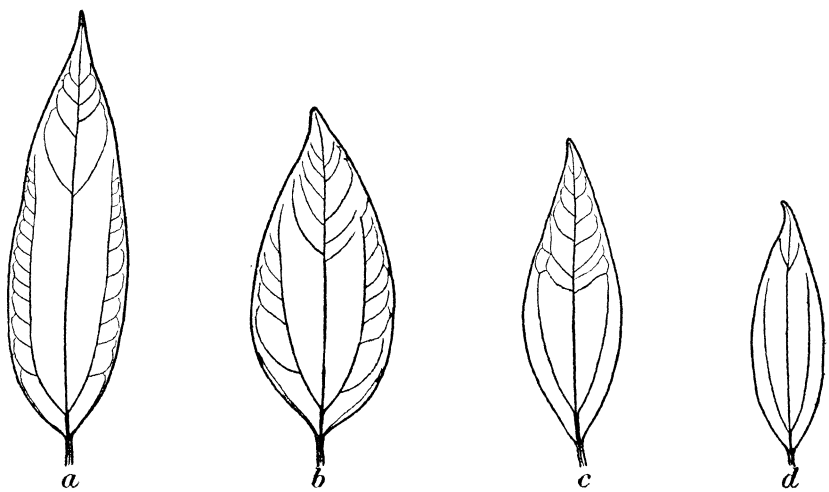

FIG. 11. *Cinnamomum burmanni*, average leaves from foreign specimens; *a*, from material ex Herb. Hort. Bot. Bog.; *b* and *c*, from Preanger, Pangentjongan, Java; *d*, from Semarung, Oengaran, Java. × 0.5.

The spongy chlorenchyma occupies about two-thirds of the entire mesophyll and, as in the other species, is composed of small irregularly shaped cells with moderate-sized air spaces. The secretion cells are rounded and measure about 0.045 millimeter in diameter. They are usually found between the palisade cells, but sometimes in the spongy region. Those in the spongy region are smaller and measure only about 0.03 millimeter in diameter, as represented on text fig. 12, *b*. The stomata appear very similar to the stomata of the other species as shown on text fig. 12, *f*. Occasionally simple unicellular hairs are also observed in the lower surface. The transverse sections of the veins bear close resemblance to the vein structure of the other

species, especially to those of *C. mindanaense*, but they are not so well developed as those of the latter.

A transverse section cut through the midrib shows the same general characteristics as that of *C. mindanaense* (text fig. 12, *a*). The shape and the distribution of tissues are similar, but the midrib is usually very much thicker and wider. The collenchyma region is rarely fan-shaped and very few secretion cells are observed in the cortical parenchyma. The cortical parenchyma region is proportionately wider or larger than that of *C. mindanaense* or the other species. The vessels measure from 0.11 to 0.018 millimeter in diameter and are also arranged in radial rows.

Surface preparation.—The structure of the upper epidermis of *C. burmanni* is also quite similar to that of *C. mindanaense*, but in the former, the epidermal cells have slightly thinner and more undulated or sinuate walls (text fig. 12, *c*). They measure from 0.03 to 0.04 millimeter in their longest diameter and from 0.020 to 0.025 millimeter in their shortest diameter (text fig. 12, *c*). Their walls measure about 0.004 millimeter in thickness, and as in the other species are faintly striated. The lower epidermis is also very similar to the lower epidermis of *C. mindanaense*, but the stomata are less numerous and larger than those of the latter. The lower epidermal cells measure from 0.018 to 0.025 millimeter in their longest diameter and from 0.006 to 0.02 millimeter in their shortest diameter (text fig. 12, *d*). The simple unicellular hairs are not so numerous, and they are only found in the lower epidermis. They differ from the hairs of *C. mindanaense* in being usually shorter and in having thicker walls. They measure only about 0.09 millimeter in length (text fig. 12, *e*).

THE BARK

The barks arrived from Java in partially dried pieces. These pieces vary from 15 to 35 centimeters in length by from 1 to 5 centimeters in width and about 0.8 millimeter in thickness. They are either in simple quills, rolled up, or in flat pieces, as those indicated on Plate 19, fig. 76. The flattened pieces apparently were collected from the younger stem of the tree, for they are thinner and more pliable in texture. The external part is greenish brown or sepia, glistening with some more or less transverse grayish brown patches and with numerous small, nearly rounded lenticels. The inner surface is chocolate brown, smooth, and very finely striated. The older barks occur in quilled

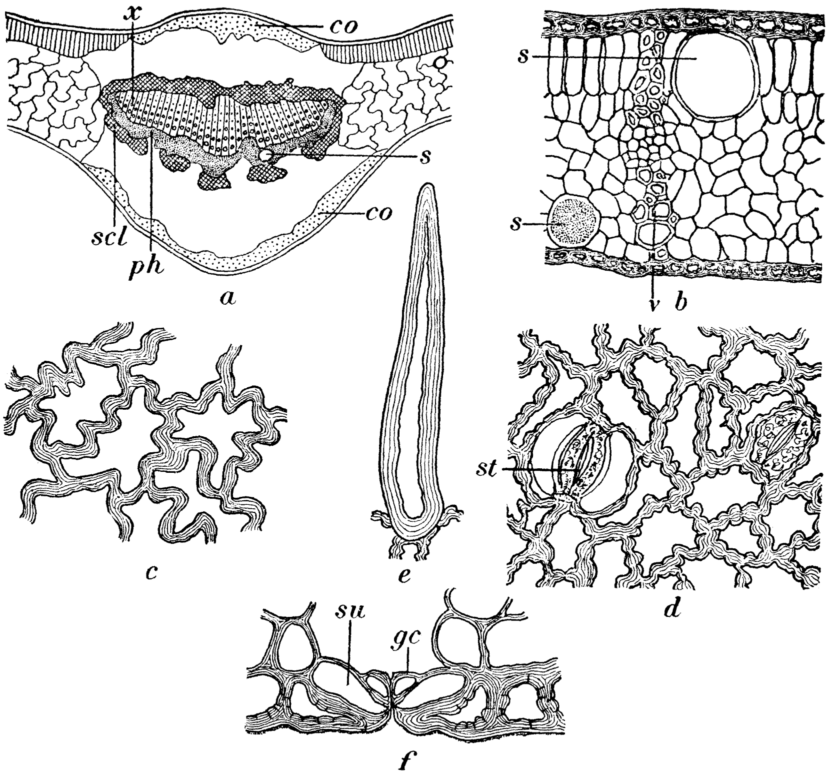

FIG. 12. *Cinnamomum burmanni; a,* a diagrammatic sketch of a transverse section of the midrib (*co,* collenchyma; *scl,* schlerenchyma; *ph,* phloëm; *x,* xylem; *s,* secretion cell); *b,* a segment of a transverse section of the blade (*v,* vein; *s,* secretion cells), × 250; *c,* a portion of the surface view of the upper epidermis, × 540; *d,* a portion of the surface view of the lower epidermis (*st,* stoma), × 540; *e,* a single hair; *f,* a portion of the transverse section of the lower epidermis (*gc,* guard cells; *su,* subsidiary cells), × 700.

pieces with the two sides rolled inward. The outer surface is grayish brown with sometimes yellowish white, axially elongated, narrow, scalelike strips of cuticle. These are produced by the shallow longitudinal fissures, which divide the cuticle into narrow and irregular, usually axially elongated, strips. The cuticle is somewhat rough with occasional transversely elongated leaf or branch scars. The middle part is finely granular and slightly fibrous. The inner surface is light brown and smooth with very fine longitudinal striation. The fracture is short, uneven, and fibrous. The odor is aromatic like that of cassia bark, and the taste is slightly astringent and sweetish.

Microscopical structure.—A transverse section of the bark is quite similar to that of *Cinnamomum mindanaense* except that the liber of *C. burmanni* contains numerous bast fibers and

fewer mucilage cells (Plate 20, fig. 79). The periderm consists of three to four layers of tangentially elongated cells. The cortical part is composed of ten to fourteen layers of tangentially elongated thin-walled parenchyma cells, most of which contain minute starch grains (Plate 20, figs. 77 and 78). Intermingled with the parenchyma cells, there are numerous secretion cells that contain mostly a yellowish essential oil. They are slightly tangentially elongated and vary in size from 0.04 to 0.08 millimeter in their longest diameter and from 0.025 to 0.04 millimeter in their shortest diameter. The innermost part of the cortex is limited by the starch sheath. The middle region is similar to that of *C. mindanaense* although the material is much younger. The stone-cell ring is very much interrupted in various places with parenchyma cells. The stone cells are either polygonal in outline or tangentially elongated (Plate 20, fig. 78). They have thinner walls than the stone cells of the same region of *C. mindanaense,* but like the stone cells of the latter, one side of their walls is slightly thicker than the other and they usually contain minute starch grains or, sometimes, calcium oxalate crystals in prismatic form. The inner part of the pericyclic region is also composed of several layers of parenchyma cells containing either starch grains or calcium oxalate crystals. Scattered along this region there are some secretion cells, some of which contain mucilage with distinct striation and some contain a yellowish essential oil.

The phloëm or bast region is rather thick, occupying about one-half of the total thickness of the section (Plate 20, fig. 79). The sieve tubes and companion cells are not prominent, some of them can only be recognized either by their undulated walls or by their nearly collapsed condition, like those of the other species described above. The phloëm parenchyma cells are tangentially elongated and those towards the periphery contain starch grains or sometimes calcium oxalate crystals in prismatic form, while those towards the cambial region are mostly empty. Scattered between the phloëm parenchyma cells, there are some small bast fibers, isolated or in groups of two cells. The secretion cells are not so numerous, and they are comparatively smaller than the secretion cells observed in the same region of the transverse section of the bark of *C. mindanaense.* The bast region is traversed by medullary rays two to four cells wide. The medullary-ray cells are radially elongated and mostly filled up with prismatic calcium oxalate crystals or starch grains

or, sometimes, with both calcium oxalate crystals and minute starch grains like those of *C. mindanaense* (Plate 20, figs. 81 and 82).

The radial section cut through the phloëm region is characterized by the much-elongated secretion cells measuring about 0.16 millimeter in length, the few spindle-shaped bast fibers, and by medullary rays eight to ten cells wide. The sieve tubes are sometimes conspicuous. They are identified by their lengths, the characteristic sieve plates, and their denser content. On Plate 20, fig. 80, a portion of the radial section cut through the bast region is indicated.

The most conspicuous elements observed in the preparations from the material macerated by Schultze's maceration process may be described as follows: (*a*) The thin and slender spindle-shaped bast fibers of from 0.08 to 0.46 millimeter in length (Plate 21, fig. 83, *a*). Their tips are sometimes sharply pointed, and their sides more or less undulated in outline. (*b*) The stone cells, as the ones found in the transverse section, are comparatively smaller than those of *C. mindanaense* or than those of the other species and they have thinner walls (Plate 21, fig. 83, *b* and *e*). They are from 0.012 to 0.04 millimeter long, and from 0.008 to 0.02 millimeter wide, with one side of their walls slightly thinner than the other. (*c*) The secretion cells are isolated or in axial groups of two or, sometimes are embedded with the phloëm parenchyma cells (Plate 21, fig. 83, *c*). They are easily identified because they usually contain droplets of a substance stainable by alkanna tincture or osmic acid solution. They vary in shape from nearly round to elongate and from 0.02 to 0.05 millimeter in length and 0.012 to 0.016 millimeter in width. (*a*) The small medullary rays in tangential view are occasionally observed surrounded by a few parenchyma cells (Plate 21, fig. 83, *d*).

SUMMARY AND CONCLUSION

1. The leaves of the above species of cinnamon trees externally exhibit great variations in various features; namely, shape, size, thickness, texture, etc. The most variable among them are *Cinnamomum zeylanicum* Blm., *C. iners* Reinw., and *C. mercadoi* Vid.; the rest and the less-variable ones are *C. cassia* Blm., *C. mindanaense* Elm., and *C. burmanni* Blm. As a whole, *C. zeylanicum* has the thickest but least-glabrous leaves with the lateral veins extending very close to the tip; whereas *C. iners*

possesses the largest average leaves, which are thinner and more glabrous than those of *C. zeylanicum,* and their lateral veins usually extend clear to the apex. *Cinnamomum mercadoi,* on the other hand, has from large to very small average leaves; the leaves of the high-altitude forms, especially, are very small. The leaves are more shiny above and glabrous below with somewhat distinct reticulate venations.

2. The leaves of *C. mindanaense* and of *C. burmanni* are very similar, but the former are usually slightly thicker than the latter and the principal lateral veins in the leaves of *C. mindanaense* usually extend about three-fourths the length of the blade, whereas in those of *C. burmanni* they extend two-thirds the length of the blade. The leaves of *C. cassia* are the thinnest and their principal lateral veins extend very close to the apex.

3. Although the cinnamon leaves exhibit much variation in their various external features yet they show great resemblance in their anatomical structure. Their epidermal cells are quite the same in characteristics except in some specimens of *C. mercadoi,* where they are papillous.

4. They all possess single layers of palisade chlorenchyma with a tendency to produce secondary narrow palisade layers as observed in *C. mercadoi* and *C. burmanni.*

5. The secretion cells of the leaves containing yellowish essential oil or, sometimes, mucilage occur in the mesophyll as well as in the midrib in all the species.

6. Simple unicellular hairs are found on the lower surface of the leaves in all the species. In *C. zeylanicum* and *C. burmanni* they are usually short, thick-walled, and scanty, while in *C. cassia* and *C. mindanaense* they are either short, or long with thinner walls, and are more numerous than those of the former; in *C. mercadoi* and *C. iners* they are usually very long with thick walls and very abundant.

7. The epidermal cells of all the species in the surface view are polygonal in outline with sinuate thick walls. The walls of the epidermal cells vary in thickness according to the species of cinnamon. The stomata are abundant and confined to the lower surface only. The guard cells are depressed and bordered and overarched by subsidiary cells.

8. The transverse sections of the midrib of *C. zeylanicum* and *C. mercadoi* are quite similar; both are somewhat flattened with fan-shaped collenchyma regions in the upper part, while the cross-sections of the midribs of *C. iners, C. mindanaense, C. bur-*

manni, and *C. cassia* are all slightly convex above and strongly convex below. *Cinnamomum iners* is distinguished from the others by the presence of very numerous secretion cells in the cortical region of the midrib, while *C. cassia* is characterized by the extension of the palisade regions to the upper part of the midrib.

9. The barks with a complete periderm of the six species and of about the same age appear very much alike, but without the suberous coat *C. zeylanicum* exhibits finer grains and smoother surfaces with longitudinal striations.

10. The structure of the barks of the six species exhibits a great resemblance. The barks of *C. zeylanicum, C. mindanaense,* and *C. burmanni* have a finer structure than those of the other three. They are all characterized by the presence of the secretion cells containing yellowish essential oil or mucilage, the remarkable stone cells in the pericyclic region with one-sided thickening, the bast fibers, the calcium oxalate crystals, and the medullary rays.

11. The secretion cells in the bark are found in the cortex, in the inner part of the pericyclic region, and especially in the bast. In *C. burmanni, C. zeylanicum,* and *C. iners* the secretion cells are numerous in the cortex. The secretion cells containing mucilage are very abundant in the bast of *C. mindanaense.*

12. The stone cells form, more or less, a complete ring in *C. zeylanicum;* are somewhat continuous in *C. mindanaense* and *C. burmanni;* but are much interrupted in *C. cassia, C. mercadoi,* and *C. iners.* They are very large with thick walls in *C. zeylanicum* and *C. mercadoi,* but thinner with a distinct one-side thickening in *C. cassia, C. mindanaense, C. burmanni,* and *C. iners.* In *C. cassia, C. iners,* and *C. burmanni* they usually contain starch grains, sometimes mixed with calcium oxalate crystals.

13. The bast fibers are found in all the phloëm regions of the above species, except *C. mindanaense,* in which they are either absent or very scanty. The bast fibers are few and small in *C. mindanaense* and *C. burmanni,* but they are large and numerous in *C. cassia, C. mercadoi,* and *C. iners.* The longest and smallest bast fibers are observed in *C. burmanni.*

14. The calcium oxalate crystals are observed in the medullary-ray cells, phloëm parenchyma, pericyclic, and cortical parenchymas, and frequently are mixed with starch grains. In *C. cassia* and *C. mercadoi* they are small and in raphide forms, whereas in *C. zeylanicum* they are either in clinorhombic or

prismatic forms and in *C. iners* are all clinorhombic or fusiform. In *C. mindanaense* and *C. burmanni,* on the other hand, they are large and in prismatic or sometimes cubical forms.

15. The medullary rays usually are from one to two cells wide in *C. zeylanicum, C. cassia, C. mercadoi,* and *C. iners;* whereas in *C. mindanaense* and *C. burmanni* they are from one to four or more cells wide. The medullary ray cells contain either brown substance, calcium oxalate crystals, or starch grains, or both calcium oxalate crystals and starch grains.

16. The above six species, therefore, can be distinguished one from another as follows:

(*a*) *Cinnamomum zeylanicum* by its large thick leaves, the two lateral veins extended close to the apex, the secretion cells usually in the palisade region, the striation in the outer part of its bark without suberous coat, the continuous stone-cell ring, and the calcium oxalate crystals in clinorhombic and prismatic forms.

(*b*) *Cinnamomum cassia* is characterized by its moderate size and very thin leaves, the palisade region usually extended over the upper part of the midrib, the secretion cells in the palisade and spongy regions, and by the coarse structure of its barks with the stone-cell ring much interrupted and calcium oxalate crystals in raphides.

(*c*) *Cinnamomum mindanaense* by the usually small and thin leaves with the lateral veins usually extended to three-fourths of the length of the leaf, the large hairs with thin walls, the fine structure of its bark with 2- to 3-cell-wide medullary ray, the bast fibers being usually wanting, the calcium oxalate crystals in prismatic form, and the numerous mucilage secretion cells in the liber.

(*d*) *Cinnamomum mercadoi* is identified by its variable size of leaves from very small to large, thick and shining above; the secretion cells usually in the second layer of palisade and spongy regions and the lower epidermal cells sometimes papillous with very thick walls and numerous simple hairs; the coarse structure of its bark with secretion cells in the medullary rays; and the crystals in clinorhombic and raphide forms.

(*e*) In *Cinnamomum iners,* on the other hand, the leaves are large and thin, glabrous below, with lateral veins usually extending to the apex, and the secretion cells are in the palisade region. Its bark is somewhat coarse in structure, the stone cells are small and in an interrupted ring; the secretion cells are small, and crystals of oxalate of calcium are in minute clinorhombic forms.

(*f*) *Cinnamomum burmanni* is recognized by its small, thin leaves, the lateral veins extending usually to two-thirds of the length of the leaves, and the secretion cells in palisade and spongy regions; and by its very long thin bast fibers, the small number of secretion mucilage cells, the medullary rays usually from three to four cells wide, and the calcium oxalate crystals in prismatic form.

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ILLUSTRATIONS

[All drawings by the author except Plate 2, fig. 8, which was made by Macario Ligaya, of the Bureau of Science. The photographs were prepared by the photographer, Bureau of Science].

PLATE 1. CINNAMOMUM ZEYLANICUM BLUME

FIG. 1. A habit sketch of a portion of a young branch with flowers. × 0.5.
2. A single flower. × 5.
3. An inner stamen, enlarged.
4. An outer stamen, enlarged.
5. A staminode, enlarged.
6. A longitudinal floral diagram.

PLATE 2. CINNAMOMUM ZEYLANICUM BLUME

FIG. 7. Photograph of the barks deprived of the suberous coat as sold in the market.
8. A detailed drawing of a portion of the stick of bark made of the overlapping thin and quilled barks without suberous coats. × 0.75.

PLATE 3. CINNAMOMUM ZEYLANICUM BLUME

FIG. 9. A portion of the transverse section of the periderm and cortex; *k*, cork; *s*, secretion cell. × 165.
10. A segment of a transverse section of the pericycle of a young bark; *pf*, primary bast fibers. × 165.
11. A segment of a transverse section of a bark without suberous coat; *sc*, stone cells of the pericycle; *sm*, secretion cell containing mucilage; *m*, medullary rays; *ph*, phloëm; *bf*, bast fibers; *ca*, calcium oxalate crystals. × 165.
12. A portion of the radial section; *m*, medullary ray; *ca*, calcium oxalate crystals; *s*, secretion cell; *bf*, bast fiber; *st*, sieve tubes; *sc*, stone cells; *sg*, starch grains. × 165.
13. Two medullary-ray cells containing prismatic and clinorhombic calcium oxalate crystals, *ca*, and starch grains, *sg*. × 700.
14. A secretion cell from the cortical parenchyma containing essential oil and surrounded by parenchyma cells which contain a few starch grains. × 250.
15. A secretion cell from the inner part of the pericyclic region containing mucilage and surrounded by parenchyma cells which contain a few starch grains. × 250.
16. A small portion of a radial section of the pericyclic region showing radially elongated stone cells. × 165.

FIG. 17. Another very small segment of the radial section of the pericyclic region; *sc*, stone cell. × 165.

PLATE 4. CINNAMOMUM ZEYLANICUM BLUME

FIG. 18. Different elements drawn from the powder; *a*, a fragment with a bast fiber and tangential view of a medullary ray; *b*, a group of parenchyma cells with thick and pitted cell walls; *c*, cork cells; *d*, a group of schlerenchyma cells and bast fibers; *e*, parenchyma cells with starch grains; *f*, fragments from the phloëm region; *g*, secretion cells; *h*, stone cells. × 450.

19. Some of the most important cells found in the macerated preparation; *a*, secretion cells; *b* and *c*, groups of stone cells arranged in rows. × 450.

PLATE 5. CINNAMOMUM CASSIA BLUME

FIG. 20. Photograph of dried bark with suberous coat as sold in the market.

PLATE 6. CINNAMOMUM CASSIA BLUME

FIG. 21. A portion of the transverse section through the periderm and cortex; *k*, cork region; *ca*, calcium oxalate crystals. × 165.

22. A portion of the transverse section of the pericycle; *sc*, stone cells; *sg*, starch grains. × 165.

23. A portion of the transverse section of the bast region; *bf*, bast fiber; *ph*, phloëm cells; *s*, secretion cell. × 165.

24. A medullary-ray cell containing calcium oxalate crystal in raphide, *ca*, and starch grains, *sg*. × 700.

25. A small portion of a transverse section of the medullary ray; *s*, secretion cell; *bf*, bast fiber; *sc*, stone cells. × 700.

PLATE 7. CINNAMOMUM CASSIA BLUME

FIG. 26. A parenchyma cell with thick, slightly lignified, pitted walls and containing calcium oxalate crystals, *ca*, mixed with the starch grains, *sg*. × 700.

27. Different types of cells drawn from the macerated material; *a*, a fragment of tissue consisting of *bf*, bast fiber; *m*, tangential view of a medullary ray surrounded by parenchyma cells; *b*, another fragment with a small medullary ray, *m*, and parenchyma cells; *c*, a group of bast fibers one of which has a small medullary ray, *m*, attached at one side; *d*, cork cells; *e*, a group of stone cells; *f*, secretion cells. × 450.

PLATE 8. CINNAMOMUM MINDANAENSE ELMER

FIG. 28. A habit sketch of a portion of a young branch with flowers. × 0.5.

29. A single large leaf. × 0.5.

30. *a*, A single flower, × 5; *b*, an inner stamen, enlarged; *c*, a staminode, enlarged; *d*, an outer stamen, enlarged.

31. A floral diagram.

32. A pistil, enlarged.

33. A cluster of mature fruits. × 0.5.

PLATE 9. CINNAMOMUM MINDANAENSE ELMER

FIG. 34. Photograph of the bark, *a–c*, without suberous coat, the last of which is about 1 meter long; *f*, photograph of the bark with suberous coat.

PLATE 10. CINNAMOMUM MINDANAENSE ELMER

FIG. 35. A segment of a transverse section of the pericyclic region; *sc*, stone cells; *s*, secretion cell; *m*, medullary ray. × 165.

36. A segment of a transverse section of the inner part of the pericyclic region; *sm*, mucilage-secretion cell; *s*, oil-secretion cell; *m*, medullary ray; *pf*, primary bast fibers. × 165.

37. A portion of the inner part of a transverse section of the phloëm region; *ph*, phloëm; *m*, medullary ray; *s*, secretion cell; *ca*, calcium oxalate crystals. × 165.

38. A portion of the radial section through the cortex and pericycle; *sm*, mucilage-secretion cell; *s*, secretion cell; *sc*, stone cell; *ca*, calcium oxalate crystals; *sg*, starch grains. × 165.

39. A small segment of the transverse section of a medullary ray indicating, *ca*, calcium oxalate crystals. × 700.

PLATE 11. CINNAMOMUM MINDANAENSE ELMER

FIG. 40. A portion of the radial section through the sclerenchyma region in the inner part of the pericyclic region, showing some of the primary bast fibers, *pbf*, and stone cells, *sc*. × 165.

41. A portion of the radial section through the phloëm region; *m*, medullary ray; *s*, secretion cell; *ca*, calcium oxalate crystals. × 165.

42. Different types of cells from the powder and macerated material; *a*, fragments from the phloëm region showing, *m*, transverse view of a medullary ray; *b*, groups of stone cells; *c*, groups of bast fibers; *d*, fragments from the parenchyma region, some of which have thick and pitted walls and contain starch grains; *e*, groups of starch grains; *f*, cork cells; *g*, calcium oxalate crystals; *h*, secretion cells from the powder and macerated material. × 450.

PLATE 12. CINNAMOMUM MERCADOI VIDAL

FIG. 43. A habit sketch of a portion of a young branch with flowers. × ½.

44. A single large leaf. × ½.

45. A single flower. × ½.

46. A longitudinal floral diagram.

47. A segment of the perianth with a single outer stamen, enlarged.

48. An inner stamen, enlarged.

49. A staminode, enlarged.

50. A pistil, enlarged.

51. Two mature fruits. × ½.

PLATE 13. CINNAMOMUM MERCADOI VIDAL

FIG. 52. Photograph of dried bark with periderm; *a*, an older bark from the trunk; *b*, dorsal view of a younger bark; *c*, ventral view of the other half of the same bark.

PLATE 14. CINNAMOMUM MERCADOI VIDAL

FIG. 53. A small segment of the transverse section through the cork region; *k*, cork; *sc*, stone cell. × 165.

54. A segment from the transverse section of the pericyclic region; *sc*, stone cell; *sg*, starch grains. × 165.

55. A segment from a transverse section of the inner part of the pericyclic region; *s*, secretion cell; *sg*, starch grains; *sc*, stone cell. × 165.

56. A segment from a transverse section of the outer part of the bast region; *bf*, bast fibers; *s*, secretion cell; *ca*, calcium oxalate crystals; *m*, medullary ray. × 165.

57. A segment from a transverse section of the phloëm region of a fresh specimen; *bf*, bast fibers; *m*, medullary ray; *ca*, calcium oxalate crystals; *s*, secretion cells; *ph*, phloëm cells. × 165.

58. Another segment from a transverse section of the phloëm region, but from dried material; *s*, secretion cell; *m*, medullary ray; *bf*, bast fibers; *ph*, phloëm. × 165.

59. A portion of a radial section through the phloëm region; *bf*, bast fibers; *ca*, calcium oxalate crystals; *ph*, phloëm cells; *s*, secretion cells; *m*, medullary ray. × 165.

PLATE 15. CINNAMOMUM MERCADOI VIDAL

FIG. 60. A parenchyma cell containing calcium oxalate crystals in raphides, *ca*. × 700.

61. Different types of cells drawn from the macerated material; *a*, a group of bast fibers; *b*, groups of stone cells; *c*, two mucilage-secretion cells; *d*, groups of cork cells; *e*, parenchyma cells with thick and pitted walls, × 450; *f*, starch grains, × 700; *g*, a group of secretion cells, × 450.

PLATE 16. CINNAMOMUM INERS REINWARDT

FIG. 62. A habit sketch of a portion of a young branch with flowers. × 0.4.

63. A single flower. × 4.

64. A diagrammatic sketch of a dissected perianth showing the relative position of the stamens, enlarged.

65. *a*, An inner stamen; *b*, an outer stamen; *c*, a staminode, enlarged.

66. A single fruit. × 1.

PLATE 17. CINNAMOMUM INERS REINWARDT

FIG. 67. A segment from a transverse section of the periderm; *k*, cork; *sc*, stone cell; *p*, phellogen layer. × 165.

FIG. 68. A segment from a transverse section through the cortex and pericycle; *s*, secretion cell containing essential oil; *cp*, cortical parenchyma; *ca*, calcium oxalate crystals; *sc*, stone cells of the pericyclic region. × 165.

69. A segment from a transverse section of the outer part of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *ca* calcium oxalate crystals; *sg*, starch grains. × 165.

70. A segment from the transverse section of the innermost part of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *s*, secretion cell; *ph*, phloëm. × 165.

71. A portion of the radial section of the phloëm region; *m*, medullary ray; *bf*, bast fibers; *s*, secretion cell; *ca*, calcium oxalate crystals; *st*, sieve tube. × 165.

72. A medullary-ray cell from a radial section containing calcium oxalate crystals, *ca*. × 700.

73. Groups of elements from the macerated material; *a*, a group of bast fibers; *b*, stone cells; *c*, cork cells; *d*, parenchyma cells with thick and pitted walls; *e*, secretion cells containing either essential oil or mucilage. × 450.

PLATE 18. CINNAMOMUM BURMANNI BLUME

FIG. 74. A portion of a young branch with flowers drawn from dried material from Java; *a*, a single large leaf. × 2/3.

PLATE 19. CINNAMOMUM INERS REINWARDT AND CINNAMOMUM BURMANNI BLUME

FIG. 75. *Cinnamomum iners; a*, photograph of a dorsal view of a piece of dried bark, collected by C. F. Baker in Mindanao; *b*, ventral view of the same piece of bark.

76. *Cinnamomum burmanni*, photograph of the dried bark, specimen from Buitenzorg botanical garden; *a*, from an older stem; *b*, from a younger stem.

PLATE 20. CINNAMOMUM BURMANNI BLUME

FIG. 77. A portion of a transverse section through the cortical and pericyclic region of a younger bark; *sc*, stone cells. × 165.

78. A section similar to the one illustrated in fig. 77, but from an older bark; *s*, secretion cell; *ca*, calcium oxalate crystals; *sc*, stone cells of the pericycle. × 165.

79. A segment from a transverse section of the inner part of the bast region; *m*, medullary ray; *bf*, bast fibers; *ca*, calcium oxalate crystals; *s*, secretion cells; *sm*, secretion cell with mucilage; *ph*, phloëm. × 165.

80. A portion of the radial section drawn from the middle part of the phloëm region; *bf*, bast fiber; *st*, sieve tube; *s*, secretion cell; *m*, medullary ray. × 165.

81. A few medullary-ray cells from a transverse section; *ca*, calcium oxalate crystals; *sg*, starch grains. × 700.

82. Another medullary-ray cell in radial section; *ca*, calcium oxalate crystals; *sg*, starch grains. × 700.

PLATE 21. CINNAMOMUM BURMANNI BLUME

FIG. 83. Different isolated elements drawn from the macerated material; *a*, a group of bast fibers; *b*, stone cells; *c*, stone cells with thinner walls, the smaller ones of which are from the cork region and the larger cells from the parenchyma region; *d*, medullary ray in tangential view with some parenchyma cells; *e*, secretion cell. × 450.

TEXT FIGURES

FIG. 1. *Cinnamomum zeylanicum*, average leaves from different specimens from the Philippines and abroad; *a*, from the garden of the University of the Philippines; *b* and *g*, from Tabogo, West Indies; *c*, from Tondo, Manila; *d*, from Bataan, Luzon; *e*, from Java. × 1/3.

2. *Cinnamomum zeylanicum; a*, diagrammatic representation of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells) ; *b*, a segment of a transverse section of the blade (*s*, secretion cells; *v*, vein), × 250; *c*, a portion of the surface view of the upper epidermis, × 540; *d*, a portion of the surface view of the lower epidermis (*st*, stomata), × 540; *e*, a single hair, × 540; *f*, a portion of a transverse section of the lower epidermis showing a stoma from a specimen from Java (*gc*, guard cells; *sc*, subsidiary cells), × 700; *g*, a segment from a transverse section of the lower epidermis of a fresh leaf, × 700.

3. *Cinnamomum cassia; a*, *b*, and *c*, three average leaves from the three Chinese specimens in the herbarium, × 0.5; *d*, a diagrammatic representation of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells; *ha*, simple hair) ; *e*, a segment of the transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *f*, portion of the surface view of the upper epidermis, × 540; *g*, portion of the surface view of the lower epidermis (*st*, stoma), × 540; *h*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700; *i* and *j*, two simple hairs, × 540.

4. *Cinnamomum mindanaense*, average leaves from the different specimens; *a*, a leaf from the specimen from Zamboanga; *b*, from Surigao; *c*, from Misamis; *d*, from a cotype specimen from Mount Apo, Todaya, Davao. × 0.5.

5. *Cinnamomum mindanaense; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, sclerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell) ; *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cells; *sc*, subsidiary cells), × 700; *d*, a segment of the surface view of the upper epidermis, × 540; *e*, a segment of the surface view of the lower epidermis (*st*, stomata), × 540; *f*, a single hair, × 540.

FIG. 6. *Cinnamomum mercadoi*, average leaves from specimens from various parts of Luzon; *a* and *d*, from Rizal; *b*, from Laguna; *c*, from Isabela; *e*, from Bontoc; *f*, from Benguet; *g*, from Mount Umingan; *h*, from Mount Bulilao, Capiz. × 0.5.

7. *Cinnamomum mercadoi; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade from a cotype specimen, *2459*, (*v*, vein; *s*, secretion cell), × 250; *c*, a segment of a transverse section of the blade of specimen *4678*, showing papillous type of lower epidermal cell (*h*, hair), × 250; *d*, a segment of a transverse section of the blade from specimen *20933*, × 250; *e*, a portion of a transverse section of the lower epidermis showing a stoma (*gc*, guard cell; *su*, subsidiary cells), × 700; *f*, a portion of a transverse section of the lower epidermis of specimen *46783*, showing also a stoma (*gc*, guard cells; *su*, subsidiary cells), × 700.

8. *Cinnamomum mercadoi; a*, a portion of a surface view of the upper epidermis, × 540; *c*, a portion of a surface view of the lower epidermis (*st*, stoma), × 540; *c* and *d*, portion of the surface view of the lower epidermis of specimen *46783* (*p*, papilla), × 540; *e* and *f*, simple hairs, × 540.

9. *Cinnamomum iners*, average leaves from specimens from the Philippines and from abroad; *a*, from Java; *b*, from Camp Kithley, Lake Lanao, Mindanao; *c*, from Eil Simaloer bij., Sumatra; *d*, from Res. Palembang, Sumatra; *e* and *h*, from Catubig River, Samar; *g*, from herb. L. Pierre *6170*. × 1/3.

10. *Cinnamomum iners; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cells); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cell), × 250; *c*, a portion of a transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells; *h*, hair), × 700; *d*, a portion of the surface view of the upper epidermis, × 540; *e*, a portion of the surface view of the lower epidermis (*st*, stomata; *h*, hair), × 540; *f* and *g*, simple hairs.

11. *Cinnamomum burmanni*, average leaves from foreign specimens; *a*, from material ex Herb. Hort. Bot. Bog.; *b* and *c*, from Preanger, Pangentjongan, Java; *d*, from Semarung, Oengaran, Java. × 0.5.

12. *Cinnamomum burmanni; a*, a diagrammatic sketch of a transverse section of the midrib (*co*, collenchyma; *scl*, schlerenchyma; *ph*, phloëm; *x*, xylem; *s*, secretion cell); *b*, a segment of a transverse section of the blade (*v*, vein; *s*, secretion cells), × 250; *c*, a portion of the surface view of the upper epidermis, × 540; *d*, a portion of the surface view of the lower epidermis (*st*, stoma), × 540; *e*, a single hair; *f*, a portion of the transverse section of the lower epidermis (*gc*, guard cells; *su*, subsidiary cells), × 700.

PLATE 1. CINNAMOMUM ZEYLANICUM BLUME.

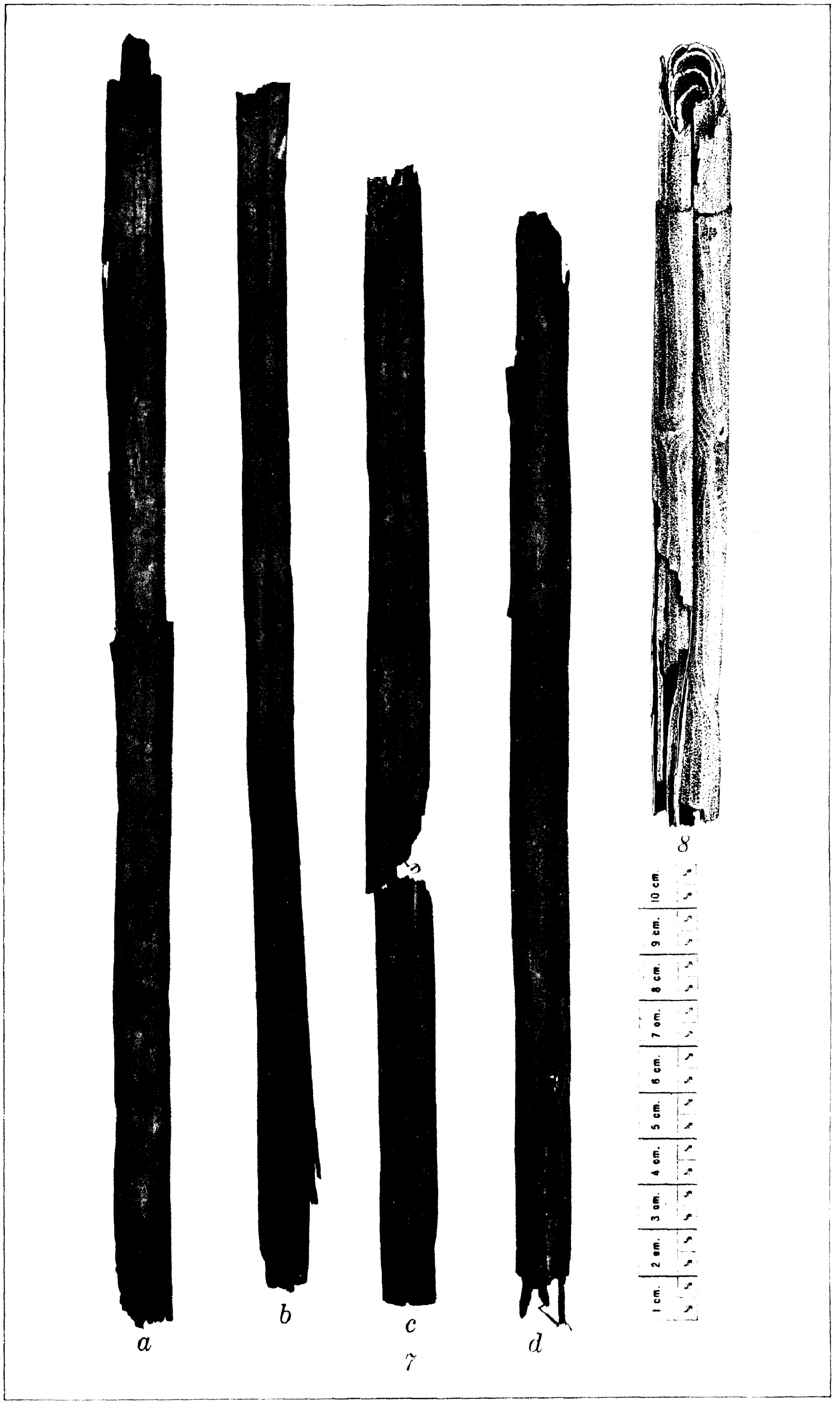


PLATE 2. CINNAMOMUM ZEYLANICUM BLUME.

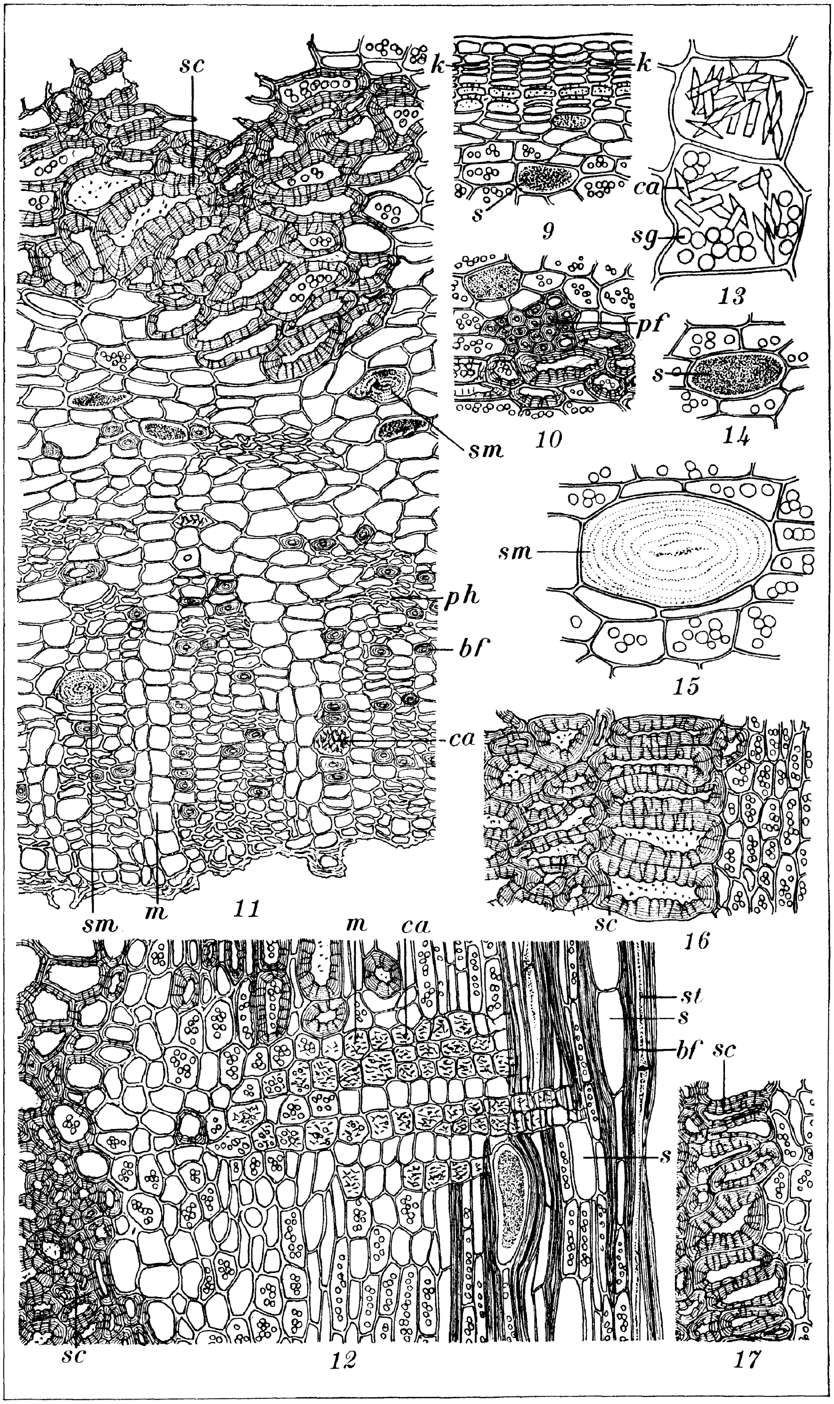


PLATE 3. CINNAMOMUM ZEYLANICUM BLUME.

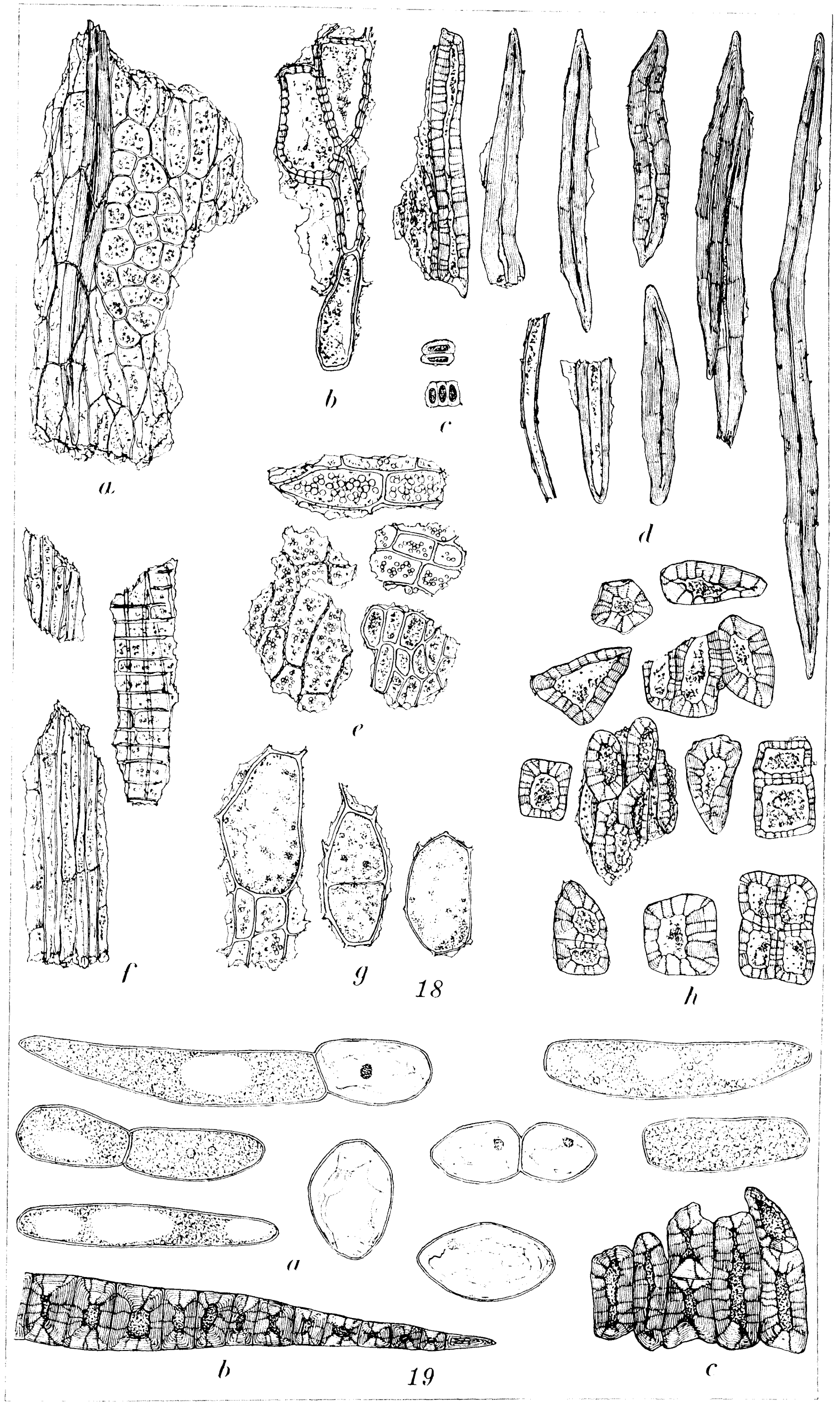


PLATE 4. CINNAMOMUM ZEYLANICUM BLUME.

20

PLATE 5. CINNAMOMUM CASSIA BLUME.

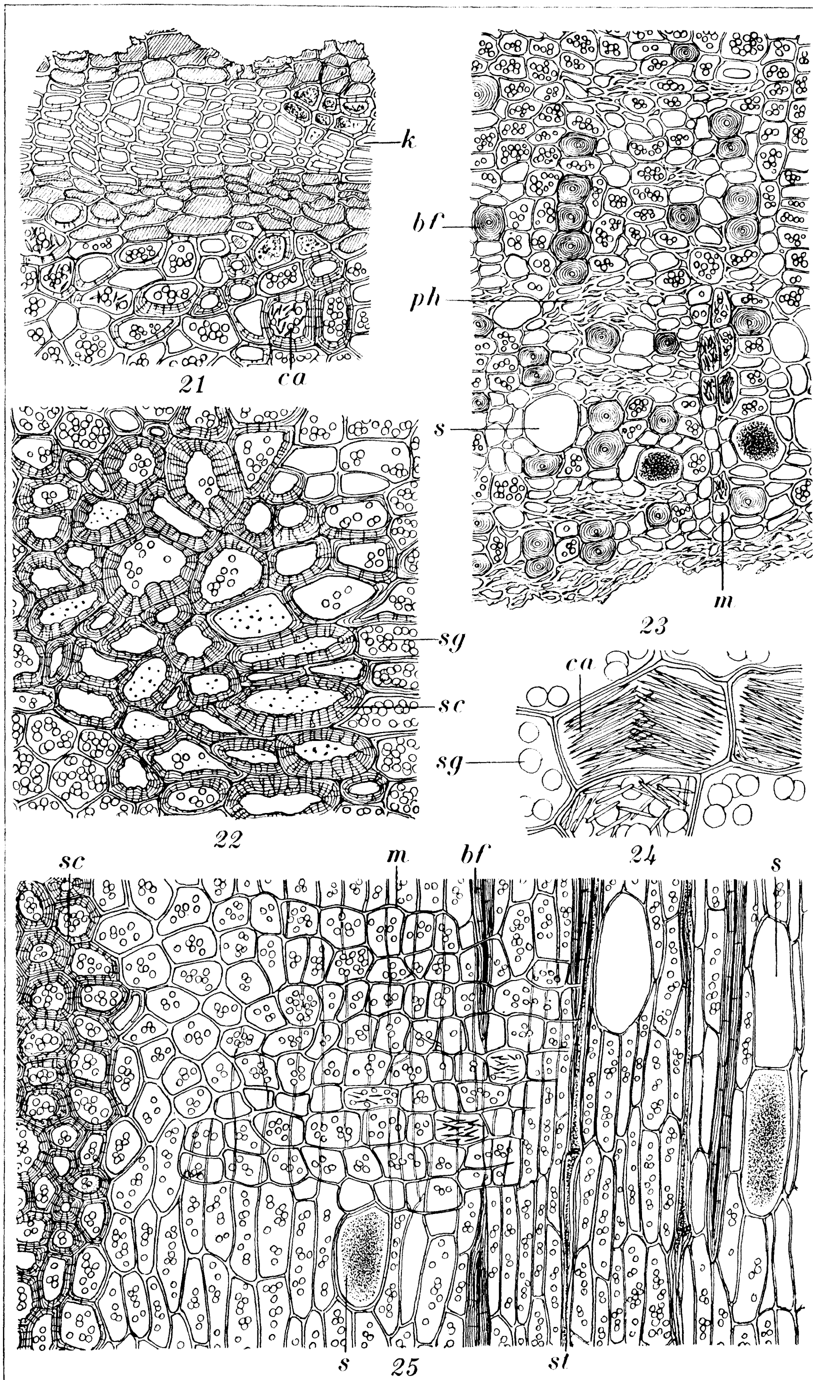


PLATE 6. CINNAMOMUM CASSIA BLUME.

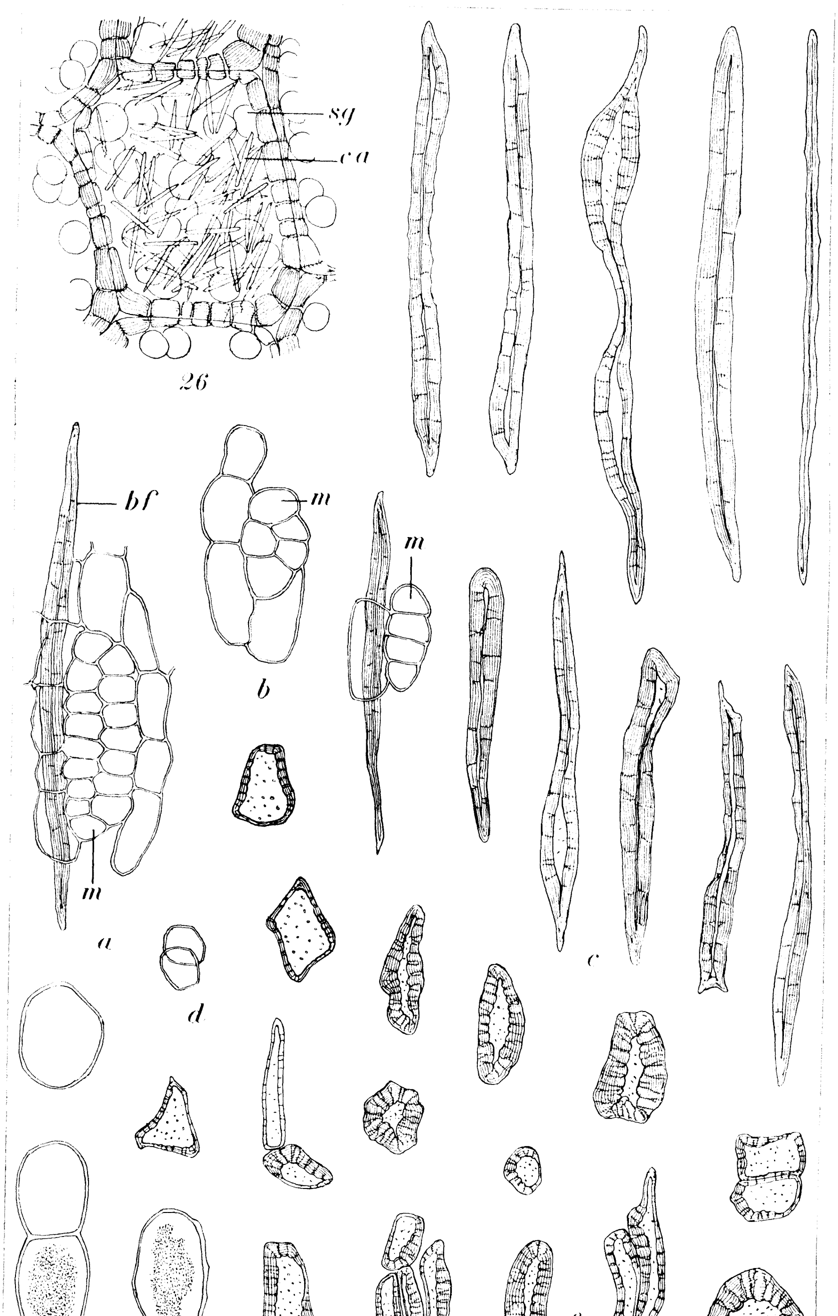


PLATE 7. CINNAMOMUM CASSIA BLUME.

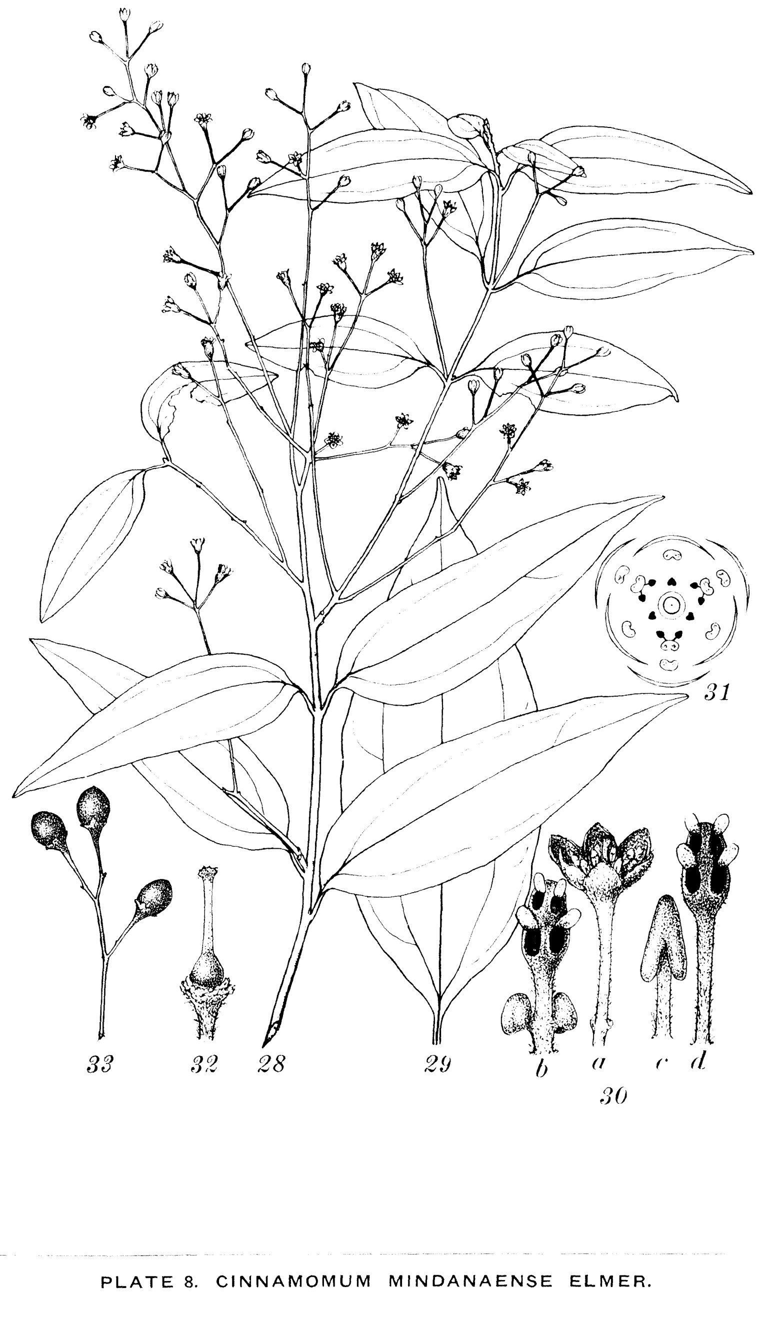


PLATE 8. CINNAMOMUM MINDANAENSE ELMER.

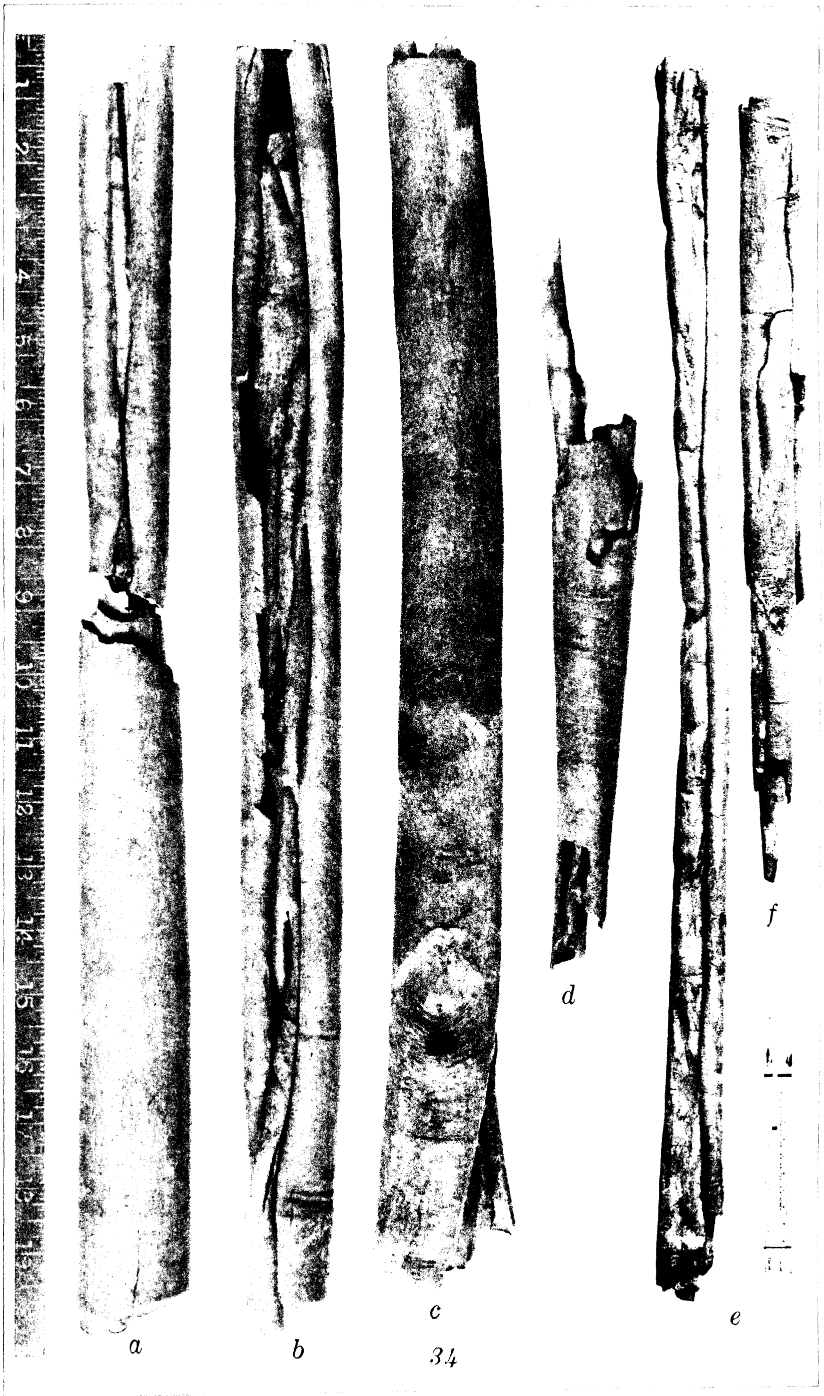


PLATE 9. CINNAMOMUM MINDANAENSE ELMER.

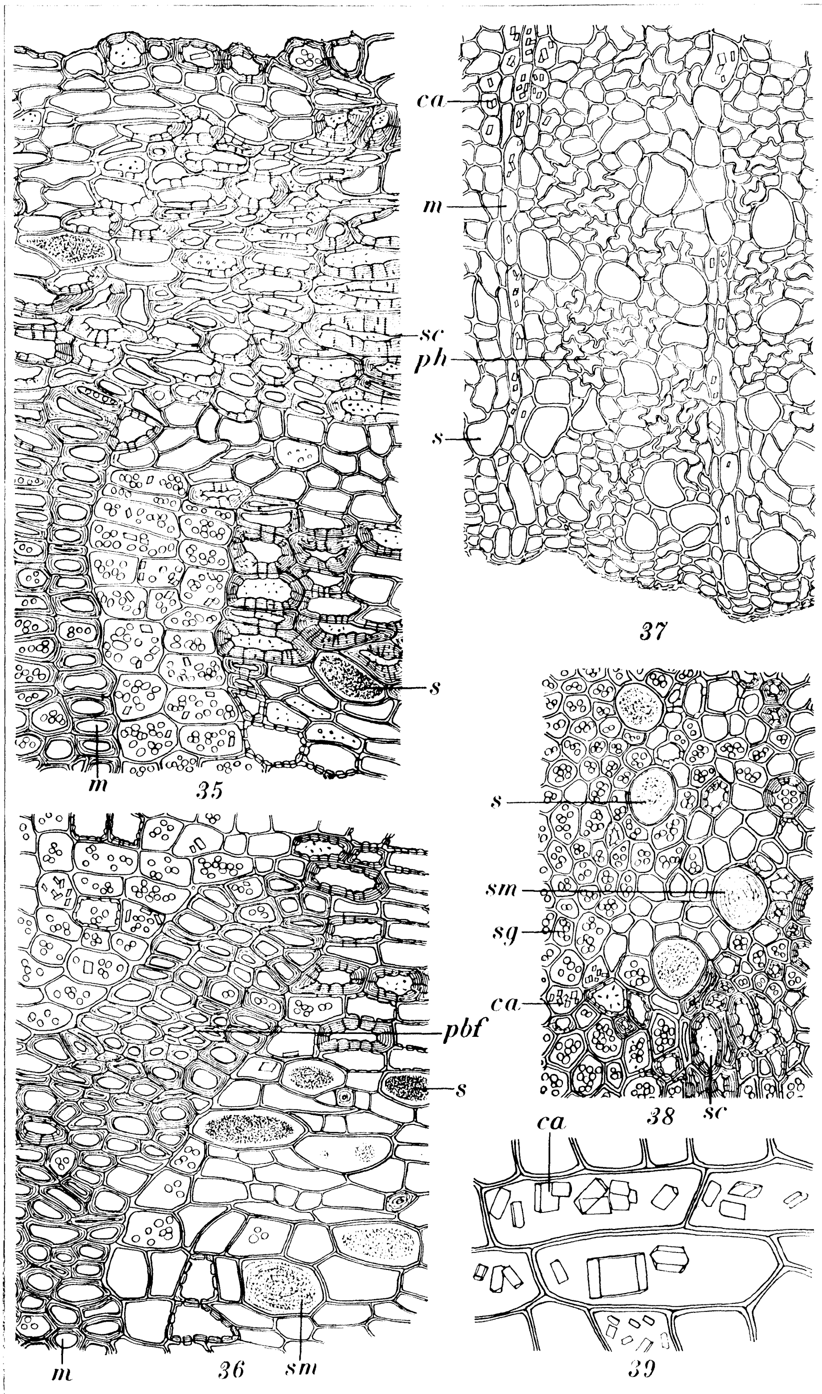


PLATE 10. CINNAMOMUM MINDANAENSE ELMER.

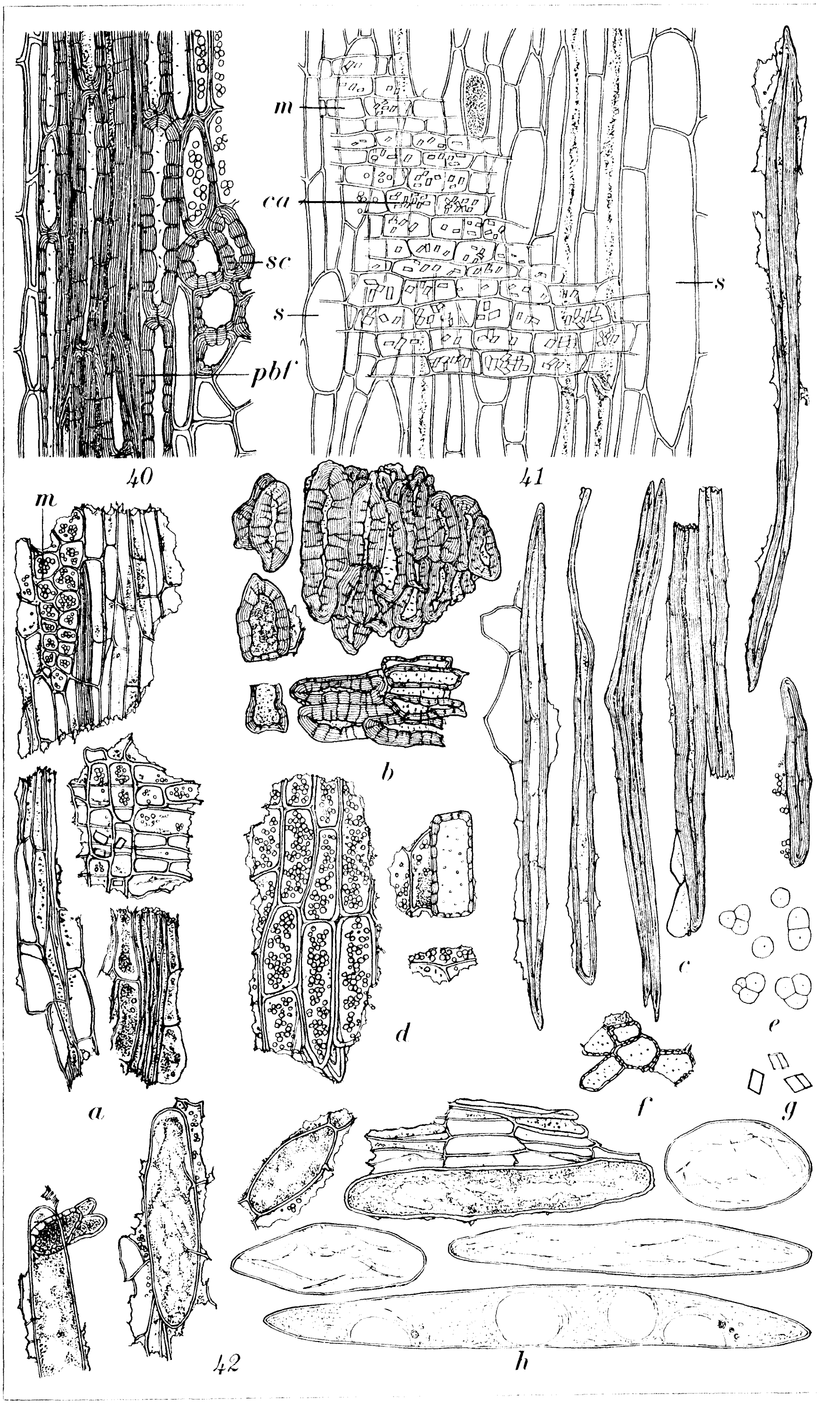
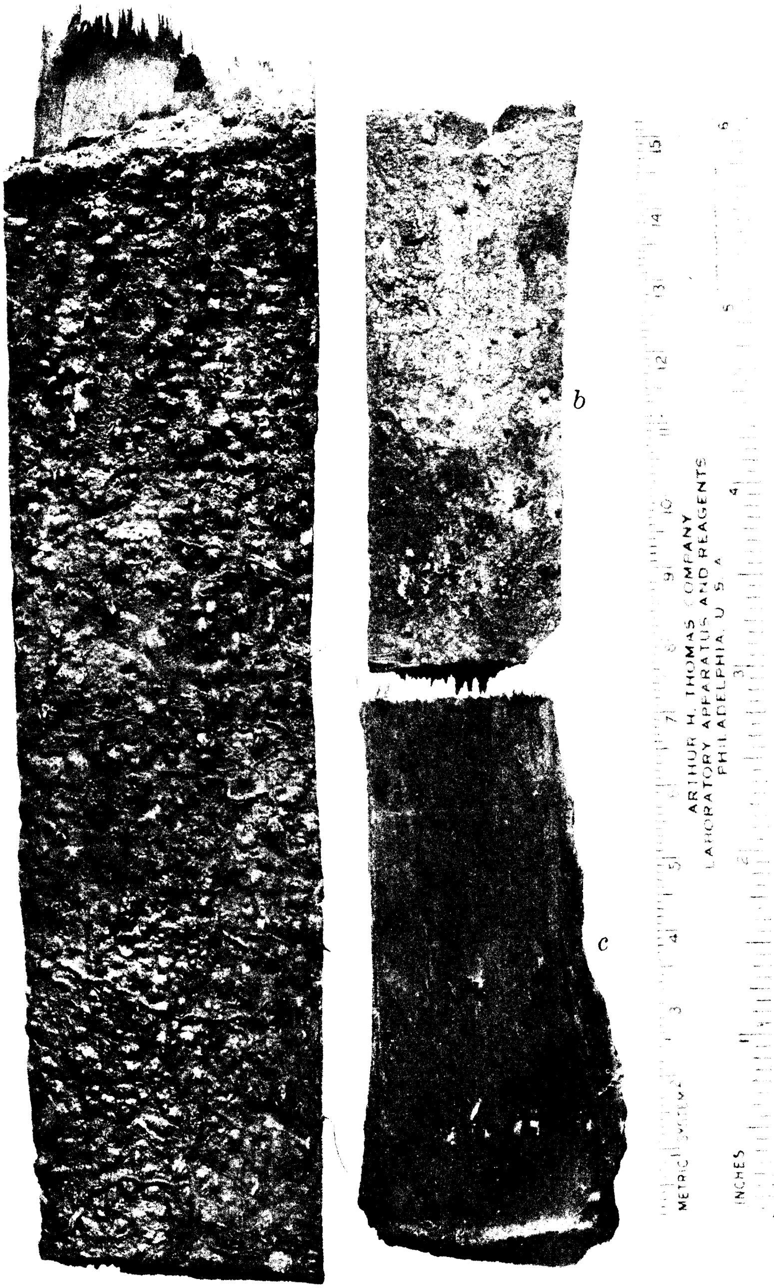


PLATE 11. CINNAMOMUM MINDANAENSE ELMER.

PLATE 12. CINNAMOMUN MERCADOI VIDAL.



a

PLATE 13. CINNAMOMUM MERCADOI VIDAL.

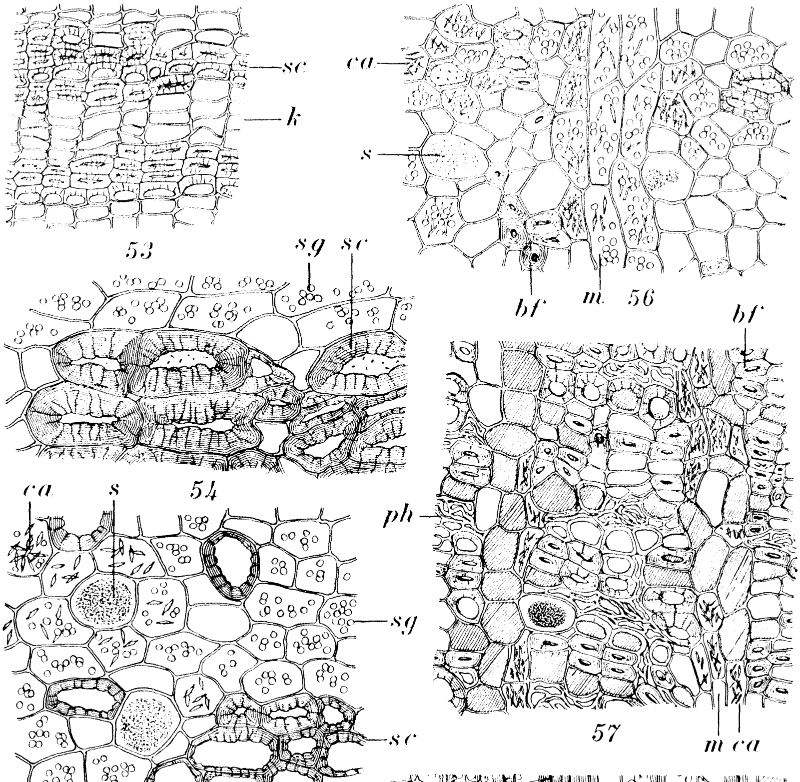


PLATE 14. CINNAMOMUM MERCADOI VIDAL.

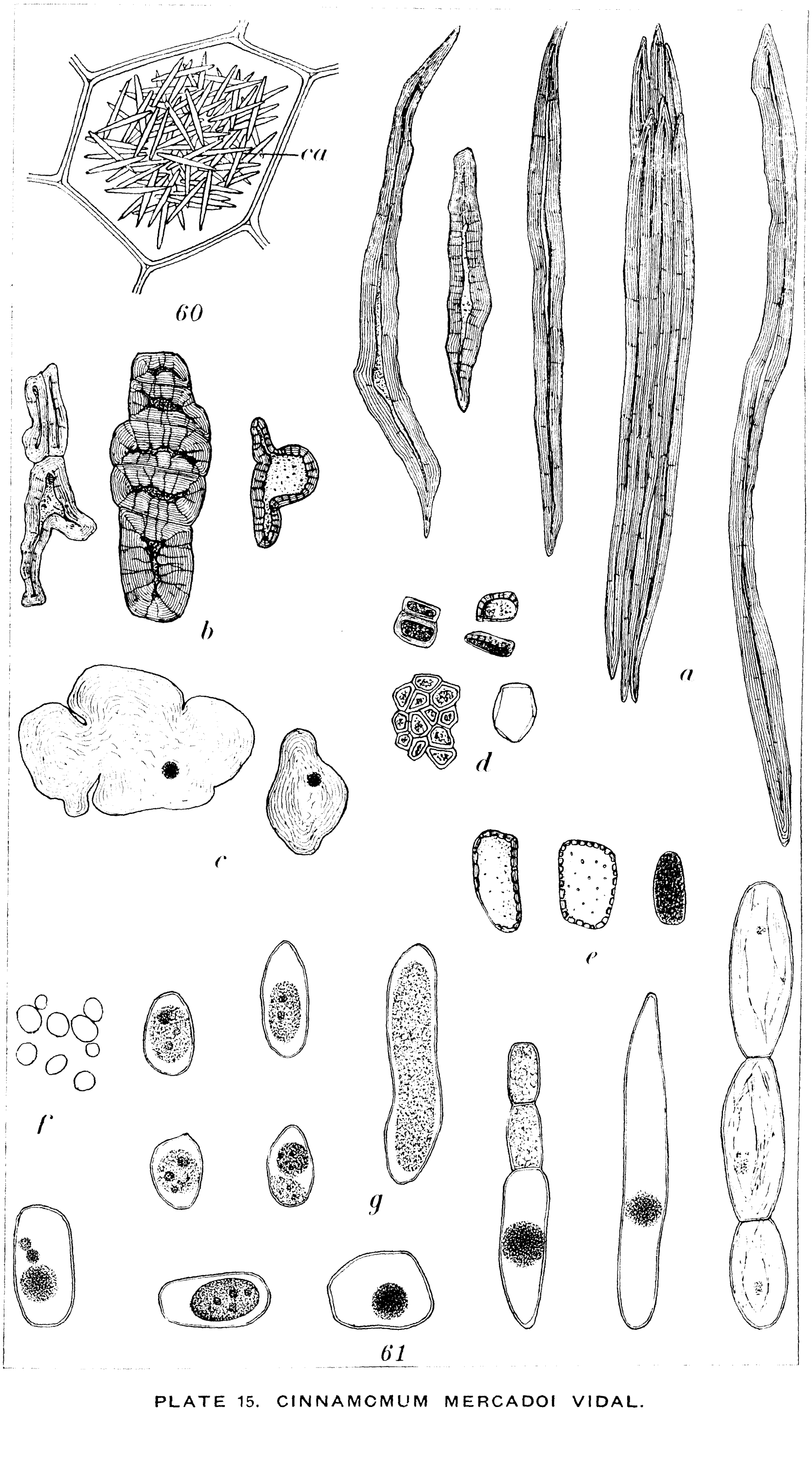


PLATE 15. CINNAMOMUM MERCADOI VIDAL.

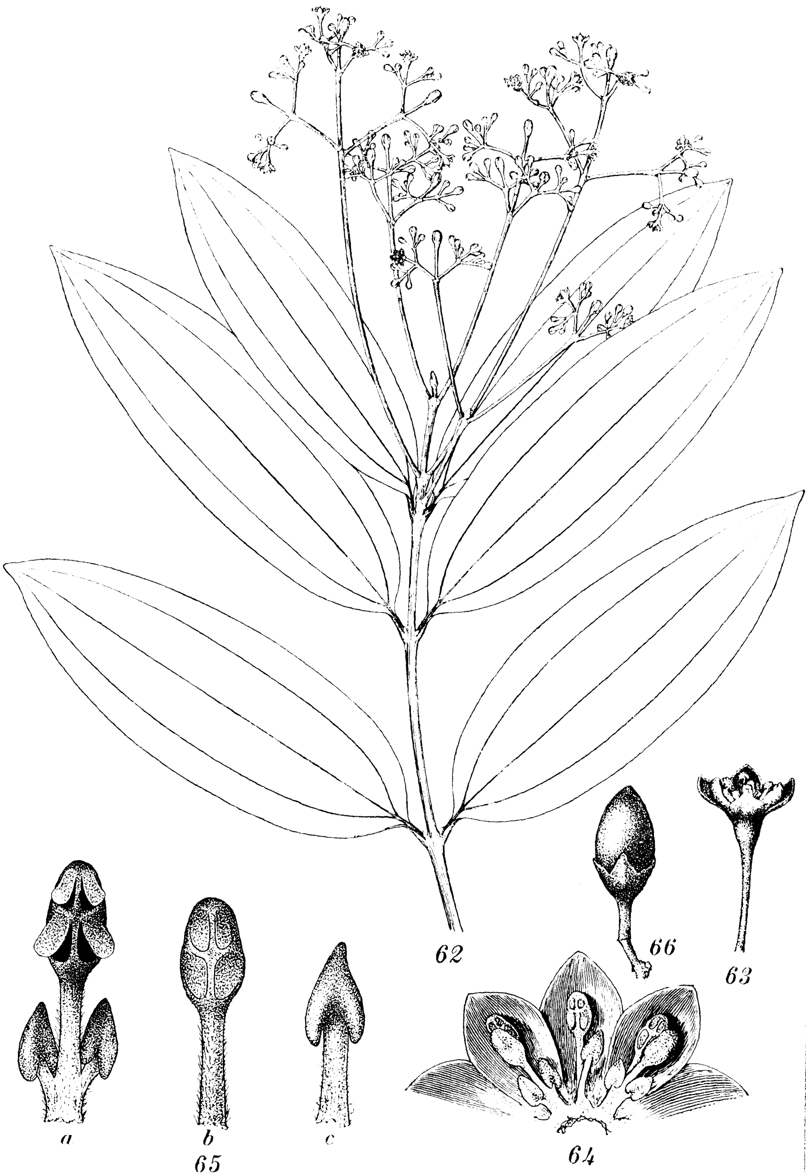


PLATE 16. CINNAMOMUM INERS REINWARDT.

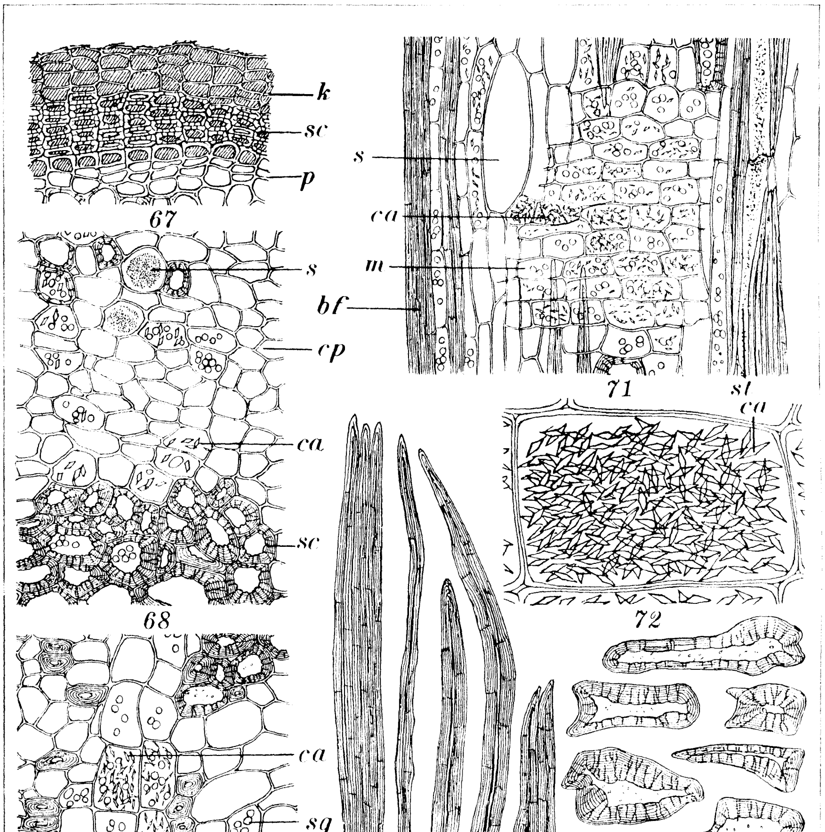


PLATE 17. CINNAMOMUM INERS REINWARDT.

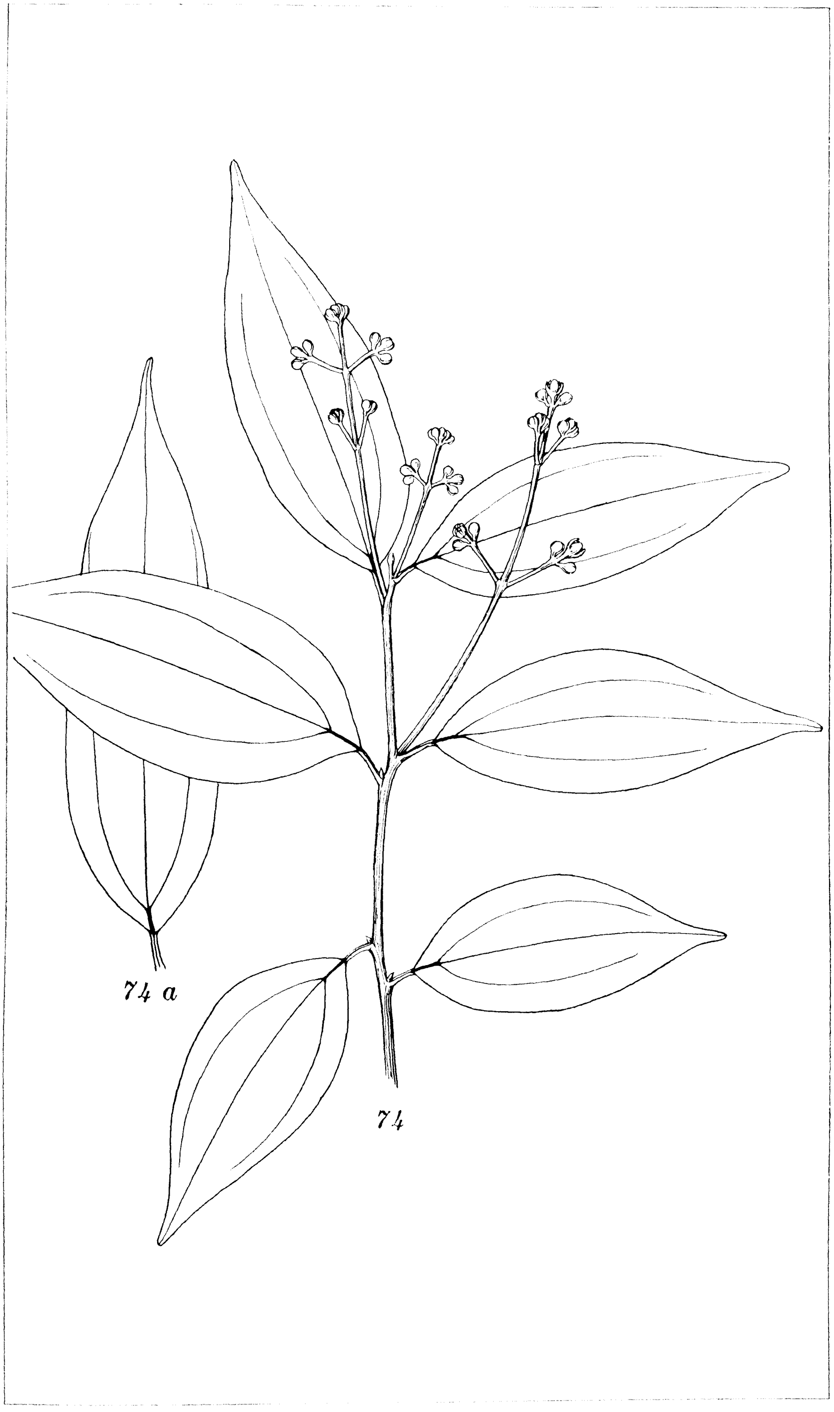


PLATE 18. CINNAMOMUM BURMANNI BLUME.

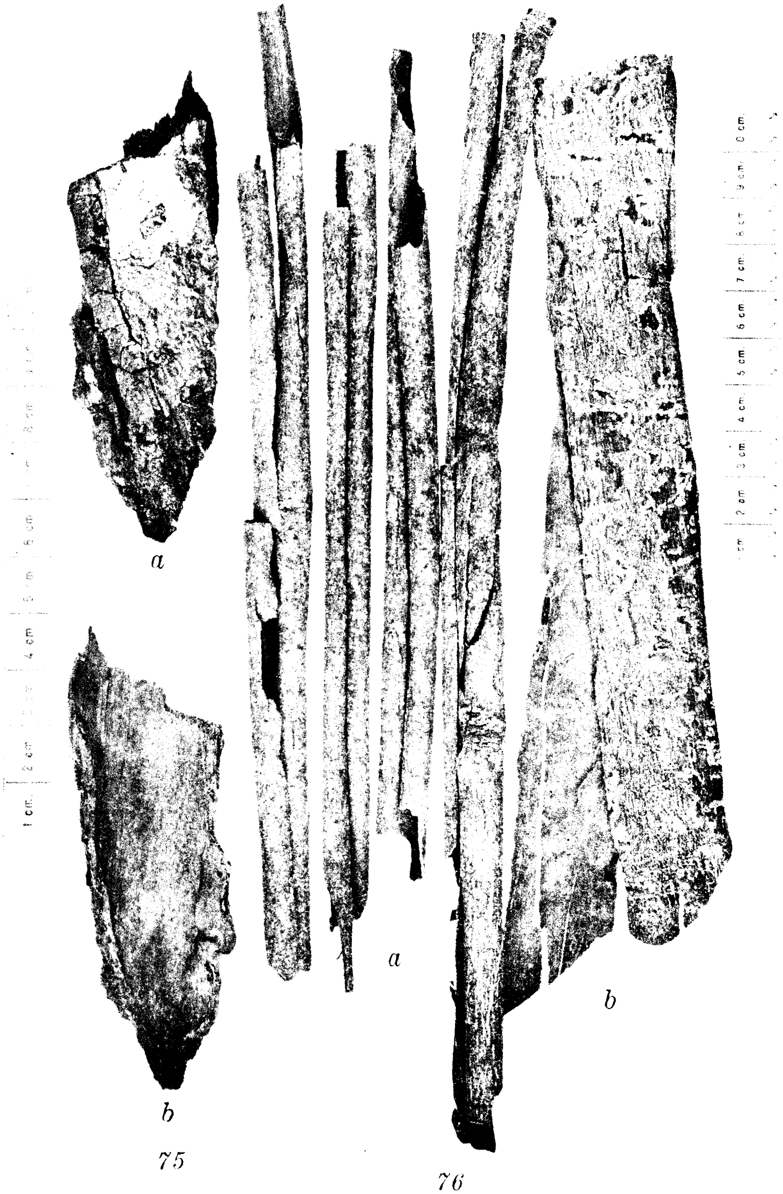


PLATE 19. CINNAMOMUM INERS REINWARDT AND CINNAMOMUM BURMANNI BLUME.

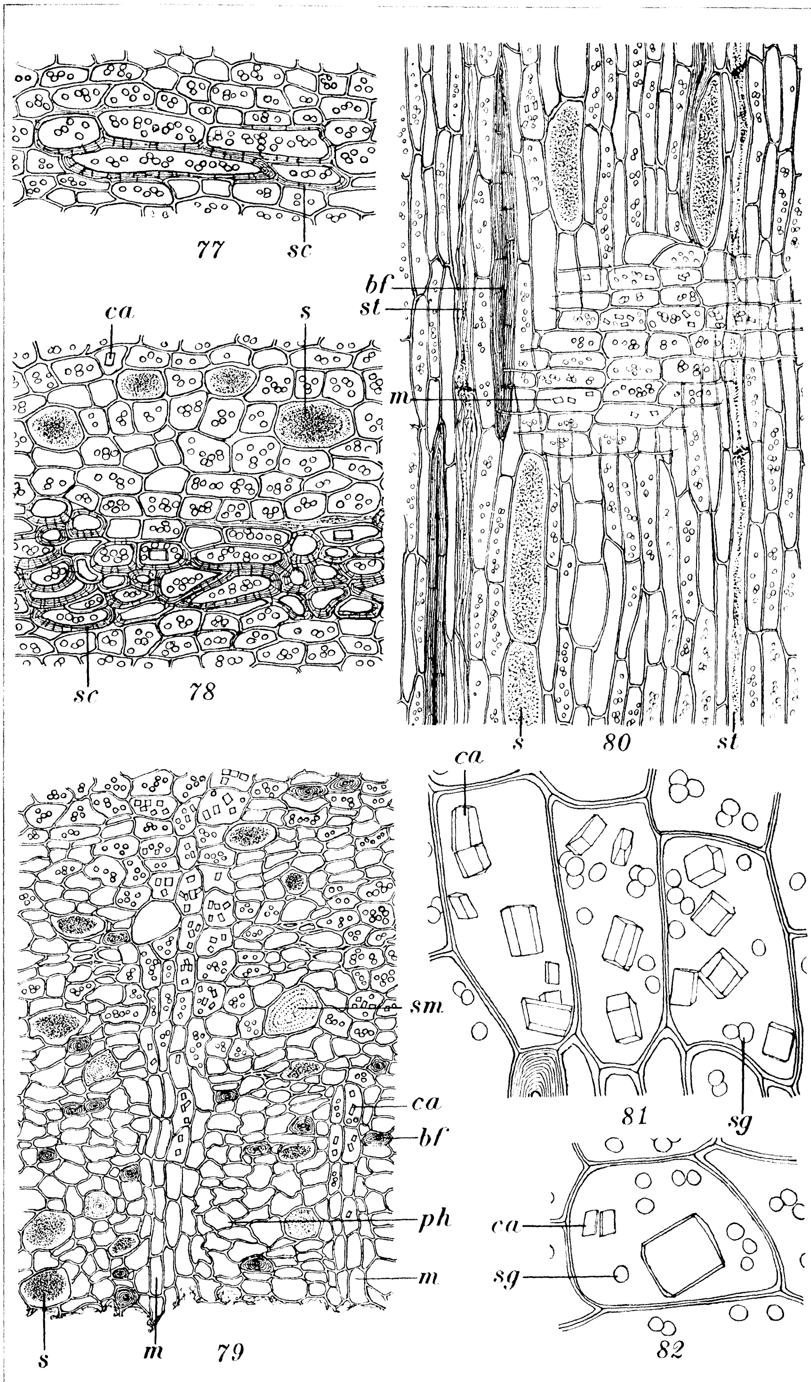


PLATE 20. CINNAMOMUM BURMANNI BLUME.

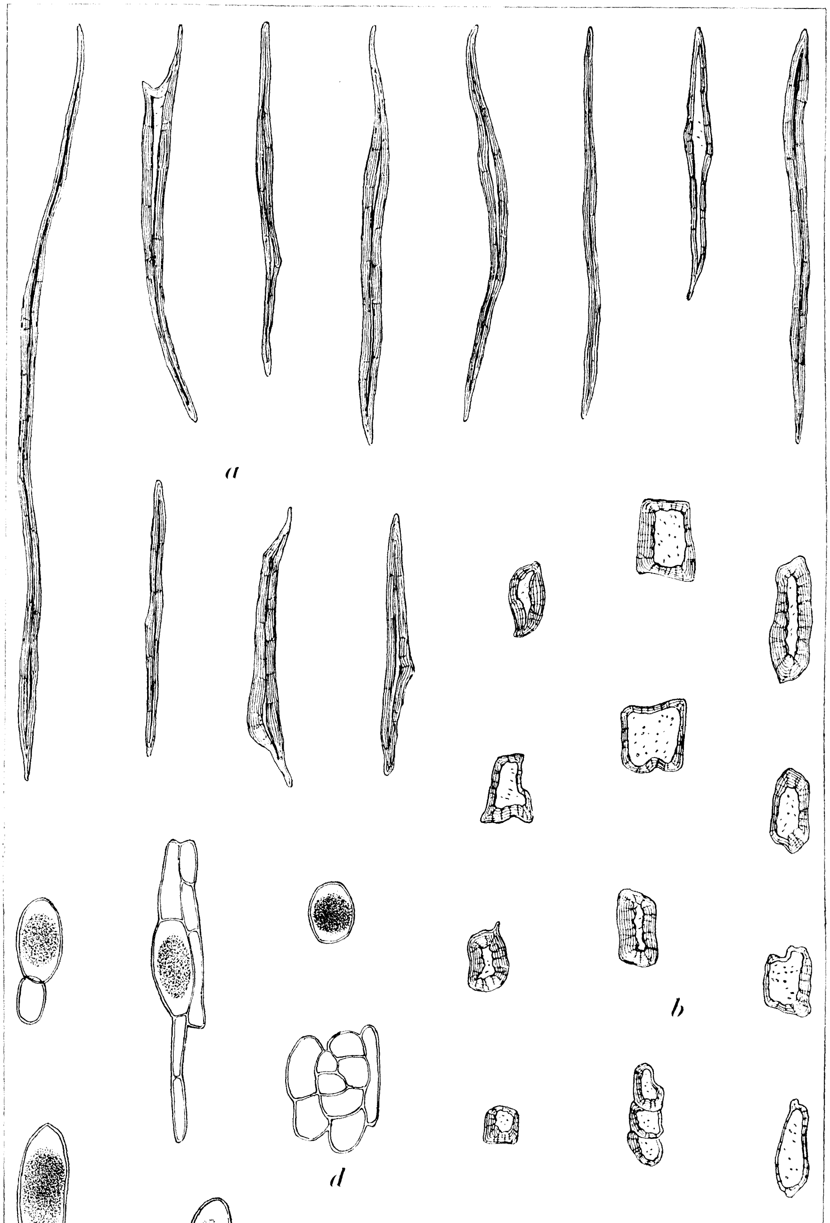


PLATE 21. CINNAMOMUM BURMANNI BLUME.

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CONTENTS

	Page.
MANALANG, C. Morphology and classification of the Philippine variety of Anopheles aconitus Donitz, 1902, and Anopheles minimus Theobald, 1901	247
SCHÖBL, OTTO. Further experiments concerning immunologic reciprocity between yaws and syphilis	263
COCKERELL, T. D. A. The xylocopid or carpenter bees of the Philippine Islands	265
ALEXANDER, CHARLES P. New or little-known Tipulidæ from the Philippines (Diptera), VII	277
SANTOS, JOSÉ K. Leaf and bark structure of some cinnamon trees with special reference to the Philippine species	305

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 43 NOVEMBER, 1930 No. 3

STUDIES ON THE DEVELOPMENT OF THE SUGAR-CANE PLANT IN THE PHILIPPINES

ROOT AND SHOOT DEVELOPMENT OF M-1900 [1]

By MANUEL L. ROXAS and MANUEL VILLANO

Of the College of Agriculture, University of the Philippines, Los Baños

FIVE PLATES AND THIRTEEN TEXT FIGURES

INTRODUCTION

The studies of the root and shoot development of the M-1900 variety of sugar cane reported in this paper were planned by the senior author and made by the junior author at the experiment station in Canlubang, Laguna Province, Luzon. Therefore, responsibility for the ideas given in this report rests mainly on the former and responsibility for the accuracy of the results is laid at the door of the latter.

Following the example of investigators in other countries in the study of the root development of the sugar cane and other plants, we started these studies in the Philippines, believing that a clear understanding of the formation and behavior of roots of the cane, under our diversified soil conditions, will dictate the best fertilizing and cultivation methods for our fields.

[1] Preliminary report 1. The results reported in this paper were obtained from the thesis presented by Manuel Villano as a part of the requirements for the degree of Bachelor of Science in sugar technology at the College of Agriculture, University of the Philippines. They are published with the permission of the Dean of the College of Agriculture.

ROOT STUDIES IN OTHER COUNTRIES

The excellent publications of Weaver and his coworkers (1–5) have furnished the background for the root studies of sugar cane conducted during the past years in Hawaii. An excellent summary of the general knowledge of the development of roots of the cane and other plants is given by Wolters. (6) However, since all discussion of the root studies in Hawaii are treated with the Hawaiian agricultural practice in mind, we will select from the original sources of information the high lights of the present knowledge of root development, having in mind their possible bearing on the practices that have resulted empirically from the different climatic and soil conditions in the Philippines.

1. It appears to be a definite conclusion that heavy root weights are correlated with heavy cane tonnage. (6)

2. Although absorption of nutrients by roots takes place throughout the whole extent of the root system, it occurs most actively in the younger and usually deeper parts. Root hairs, the organs of absorption of the roots, are limited to the younger portion except the zones of division and elongation. However, the abundance of root hairs is dependent on water content and air supply; there are very few in very wet soil. Roots die in stagnant water. (5)

3. While frequent light showers during the planting season or too early application of irrigation water will induce the formation of shallow root systems, a period of drought or the proper cultivation method will stimulate the formation of deep roots. The formation of roots is greatly governed by the distribution of moisture in the soil. (4)

4. The old idea of chemotropism, according to which, roots will deliberately follow a rich source of nutrients, must be modified in the light of the experiments of Weller. (7) Roots develop according to a hereditary habit, which may fix their form and direction. The expansion of the roots, however, depends on the conditions immediately surrounding the roots. When a root stem or branch, in its progressive development, encounters a layer of rich moist soil, extensive branching and root-hair formation will occur mostly in this layer, though the effect will not be limited to that layer, but increases will be stimulated throughout the whole root system of the cane.

5. However, Weaver demonstrated that in the case of the plants used by him, the penetration of the roots to the lower levels is retarded by such a rich layer, if diffusion of nutrients from one layer to another is prevented. Quoting from him,

> In every case where roots came in contact with a fertilized layer they not only developed much more abundantly and branched more profusely, but such a layer apparently retarded normal penetration into the soil below. Thus, it seems that the depth at which the fertilizer is placed in field practice would considerably affect root position and development. Fertilizing the surface layers of soil in regions where these have very little or no available water during periods of drought, would appear to be distinctly detrimental to normal crop production.

6. Contrary to statements made recently by some investigators, the deep layers of soil are just as important as the surface layers to the life even of those plants with 70 per cent of their root system in the 8-inch topmost layer. To quote from Weaver(3) again,

> * * * since the roots of crop plants are found to penetrate just as deep or even deeper under field conditions as in the containers used in these [Weaver's] plot experiments and since their development in every respect has been found to be identical, we must conclude that the deeper soils are not only suited to plant life, but that they play an exceedingly important part in the life of the plant and deserve careful consideration in a study of crop production.

However, the results of our present work are not in line with the experience of Weaver, as root penetration in our box experiment is much deeper than in the field experiment.

7. *Distribution of the roots of the sugar-cane plant.*—The investigations carried out by the Hawaiian Sugar Planters' Experiment Station, in which the method of excavation proposed by Lee(8) was used, have shown that in mature canes, "about 70 per cent or more of the roots were found in the topmost 8 inches of soil."(6)

8. While it has been demonstrated that a very large proportion of the root masses of the cane is in the topmost 8 inches of soil, no experiments similar to those conducted by Weaver on the rate of absorption by roots in different levels have been done with the cane, so that nothing definite is known with regard to the relative physiological importance of the 70 per cent in the topmost 8 inches, and the 30 per cent in the lower levels. Until

this relative physiological value is known, no one will be in a position to form a well-balanced judgment of the function of the different parts of the root system of the cane, or to say that soil levels where only very small masses of root are found are of little value to the crop and may be left out of soil studies. On the contrary, their nature may, for all we know, determine the success or failure of a crop under extreme conditions of drought and rainfall.

9. A recent publication by T. S. Venkatraman and R. Thomas(9) gives the results of studies of sugar-cane roots at various stages of growth. From the point of view of root distribution, perhaps the most interesting habit of the cane roots discovered by these authors is the difference in the aërotropism of the roots of different varieties. For instance the sett roots of Striped Cheribon (a noble cane) are more aërotropic than those of Katha, an Indian cane not quite intolerant to water logging. This aërotropism of the roots of canes will help explain the tendency to have more roots towards the surface. The following summary and conclusion are from the article of Venkatraman and Thomas:

> During the germination or sprouting of sugarcane setts, the development of roots from the dormant root eyes is one of the first activities.
>
> The roots thus developed from setts have been styled "sett" roots in contrast to "shoot" roots which are developed later from the shoots.
>
> There is no correlation between sett root production and the sprouting of buds. For the full development of the bud into a shoot, however, sett roots are essential.
>
> Interesting differences exist between cane varieties in the number, length and functioning period of sett roots produced during germination. In certain cases only a portion of the root eyes produce roots, the rest remaining dormant till a need arises. This is considered to be a definite and valuable provision against possible adverse conditions during the later stages of growth.
>
> Irrigation with saline water is harmful to sett root development and should be avoided.
>
> In most canes, sett roots die after a time and, subsequent to this, the plants are dependent on 'shoot' roots developed later from the young growing shoots.
>
> The rate of growth of the above ground portion of the cane plant is positively correlated with the growth vigour of shoot roots and the study of these roots thus becomes a matter of great importance to the cane grower.

During the adult stage of the cane plant there is almost a continuous development of new roots, resulting in a constantly changing root system which readily adjusts itself to changes in the environment.

If the cane is prevented from thus developing new roots, it gradually loses vigour and dies.

It is desirable to work out for each variety its typical root system and find out exactly where (in the soil) and when the series of successive new roots are developed. Such knowledge would materially help in indicating beforehand the conditions under which the variety is likely to do its best. It would further be of great use in guiding manurial and cultural operations with the maximum advantage to the growing crop.

Sett roots differ from shoot roots in certain respects, the generally greater growth vigour of the latter being the most important difference.

The observed differences between the two classes of roots arise, it is suggested from differences in the condition of the canes giving rise to each class.

Certain interesting adaptation in sugarcane roots, such as aërotropic curvatures and arrangements for ensuring an efficient rooting, are briefly described.

CANE-ROOT STUDIES IN THE PHILIPPINES

Past work.—The paper of Lee and Bissinger (10) is the only cane-root study that has been published in the Philippines.

OBJECT OF THE PRESENT WORK

Purpose explained.—The root system of cane has been studied principally from its vertical distribution. As a result of these studies, great significance has been attached to the discovery that 70 per cent of the root mass is in the topmost 8 inches of soil.

A complete picture of the root habit of the cane plant cannot be given by distribution studies in one direction only. Therefore, studies in two directions seem desirable.

Also, in spite of Wolters's statement quoted under 1 above, there seems to be some contradictory evidence as to the absolute correlation between shoot and root weights, as affected by fertilizers, and it was thought that parallel determinations of these weights, taken during the early development of the cane plant, both fertilized and unfertilized, would give more conclusive proof of such a dependence.

METHODS AND MATERIALS USED IN THESE STUDIES

Two parallel series of studies were carried out. One series was with a modified-box method described below, and the other in plots under actual field conditions.

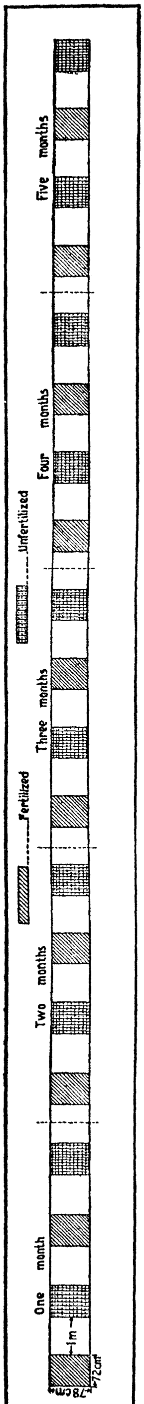

FIG. 1. Showing the arrangement of the modified-box experiment.

The modified-box method.—The box method of studying root development of crops has been criticised on the score that conditions obtaining in the boxes are abnormal. In the first place, soil that has been more or less thoroughly aërated is used. In the second place, the soils in the boxes had to be watered to make them compact. The aëration and the watering made the conditions in the boxes more favorable for growth than in the field. However, as it was deemed desirable to actually see the root conformation of the cane, and not simply reconstruct it from the weights found in the different sections both horizontal and vertical, it was decided to carry out the modified-box experiments alongside the field studies. Field conditions were approximated as far as possible. This was accomplished as follows:

Setting the modified-box experiments.—On a hillock with a rather abrupt slope, holes 78 and 72 centimeters were dug to a depth of 36 inches (fig. 1). Each 6-inch layer of soil was dug out separately from the other layers. A hillock was selected for the box experiments in order that the washing of the roots at the time of the excavation could be done more easily. Each hole was fitted at the four corners with wooden posts, 8 by 3 by 100 centimeters. To these posts were nailed the five frames holding the wire netting. The holes were filled with soil as follows: First the lowest shelf of wire netting was placed in position and nailed to the posts. Then the corresponding subsoil layer was placed on top of the shelf, packed down, and watered to make the soil set to its original condition. Subsoil was thus put on until the level of the next higher shelf was reached. This second shelf was then put on and similarly nailed to the posts. The corresponding layer of subsoil was again replaced, compacted as in the first layer, and the process was thus continued, layer by layer, until the last shelf and the top-

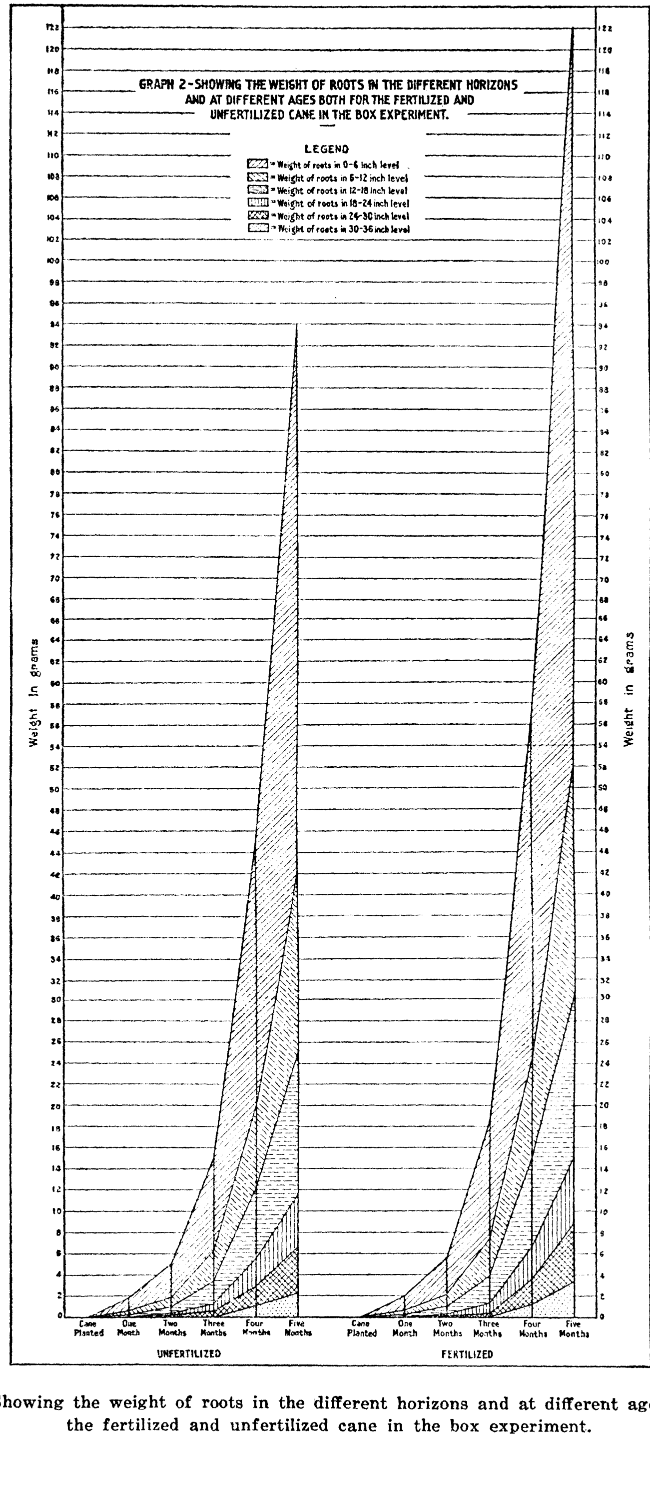

FIG. 2. Showing the weight of roots in the different horizons and at different ages both for the fertilized and unfertilized cane in the box experiment.

most soil layer were replaced. Finally, water was allowed to percolate through all the layers to make the soil as compact as it was before digging. A well-selected point of Mauritius 1900 was planted in the topmost layer of the box. The soil around the growing cane was hoed as often as necessary.

Excavation of the roots.—A deep ditch was made at the lowest end of the row of boxes, for the reception of the water and the washed soil from the boxes. As the sides of the holes were left open, it was expected that the roots of the cane extended beyond the wire shelves. Therefore, in starting the excavations, ditches were dug on the sides of the original holes first and any root masses found were collected separately for every 6-inch layer and later placed together with the roots from the corresponding layers in the wire netting. After ditches were dug around the frames, the roots were washed off and the whole frameworks with their load of roots and cane shoots removed and photographed. Then the roots were cut, beginning from the lowest and proceeding to the topmost layer, put together with the corresponding layer collected from the sides, and stored for drying and weighing in the laboratory.

The field experiment.—The field experiment was located on level ground some 200 meters from the box experiment described above. The type of soil in the two was the same; light clay derived from volcanic tuff. However, the lot for the field experiment had richer soil.

The field was 50 by 15 meters and divided into lots 5 by 5 meters. There were thirty lots in all, arranged in six groups of five as shown in fig. 5. Three alternating groups received fertilizers. The remaining three served as controls. Twenty-five well-selected points of Mauritius 1900 were planted in each plot, one at each corner of the 1-by-1-meter square. Such a spacing, locally called *dama-dama,* was necessary to reduce to the minimum the competition between roots of adjacent stools. The fertilizer was applied by mixing it with the soil deep below the point at the time of planting.

Excavation of the roots.—In each section a group of four stools in the middle of each plot was selected. Each stool was excavated separately. In all, twelve stools for the fertilized and the same number for the unfertilized were dug out each month. The method of digging was by sectioning in two directions, horizontally and vertically. This is shown in fig. 6. The vertical sections were at intervals of 6 inches and are indicated

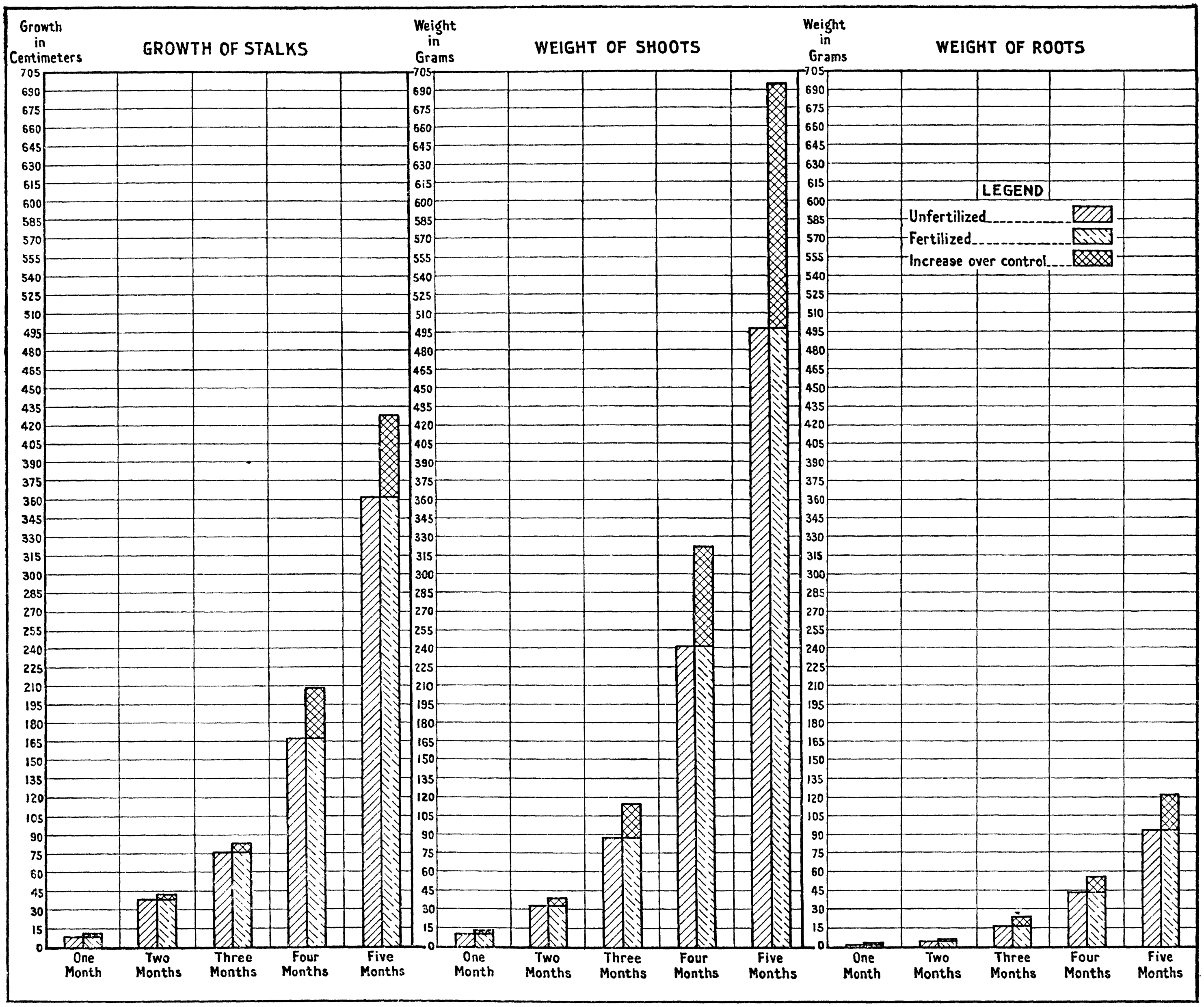

FIG. 3. Comparing growth, weight of shoots, and weight of roots of the fertilized and the unfertilized stools in the modified-box experiment.

254210—Facing page 374.

from top to bottom by subscript numbers 0, 1, 2, 3, etc. The horizontal ones were at intervals of 12.5 centimeters, or 4.92 inches, and are designated from inside out by the letters A, B, C, and D. Thus: A, B, C, and D are the sections in the first horizon, or the "0–6;" A_1, B_1, C_1, and D_1; those in the second, or "6–12" horizon, etc. As in the Hawaiian method, the soil dug out was thrown onto a wire screen held in a wooden frame. The roots were collected, placed in bags, properly labeled, and taken to the laboratory for drying and weighing.

GROWTH AND WEIGHT OF THE SHOOT

Lineal growth measurements were taken of the stalks of the selected stools. All the leaves of the selected stools were collected as they dropped from the stalks and saved, later to be added to the rest of the corresponding shoot materials. At the time of digging, the shoots were cut close to the ground, immediately chopped into small pieces, and dried in the sun to prevent fermentation and loss of solid matter from rotting. The remaining stumps were dug out with the roots, and afterwards separated from them, chipped into pieces, and mixed with the rest of the shoot materials.

After all the materials were collected and sundried, they were taken to the College of Agriculture, where after being dried in the oven at 105° C. to constant weight they were weighed in a chemical balance.

RESULTS OF THE EXPERIMENTS

The box experiment.—The results of the modified-box experiments are given in Tables 1, 2, and 3, and visualized in figs. 2, 3, and 4.

Table 1 gives the results of the excavations for each month. It gives the weights and percentages of the roots at different levels for the different months.

Table 2 gives the average rate of growth of stools under different treatments.

Table 3 gives the total weights per stool of shoots and of roots, and the ratio of tops to roots, both for the fertilized and the unfertilized cane for the different months.

The field experiments.—The results of the field experiments are given in Tables 4, 5, and 6. They are visualized in figs. 7, 8, 9, 10, and 11.

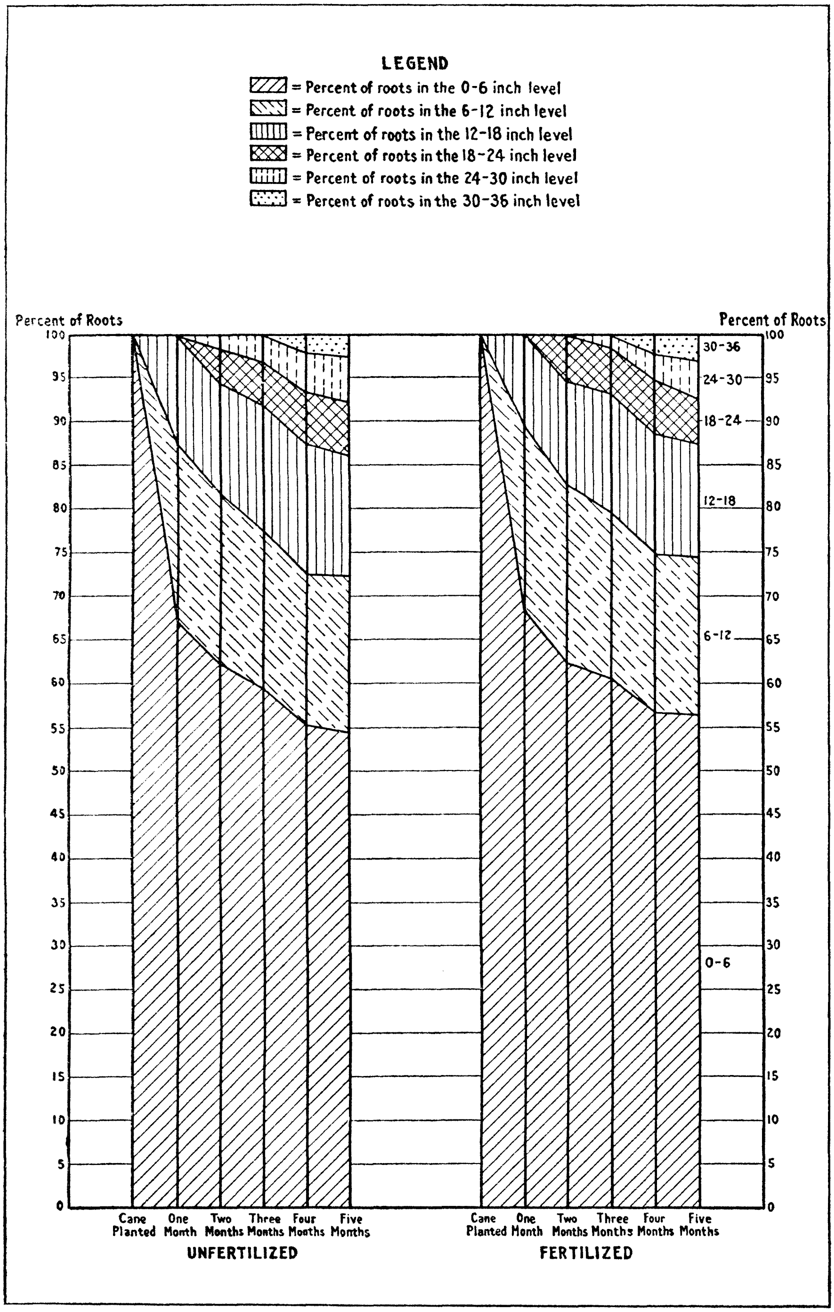

FIG. 4. Showing the distribution in percentages of the total weight of the roots in the different horizons of M-1900 in the modified-box experiment.

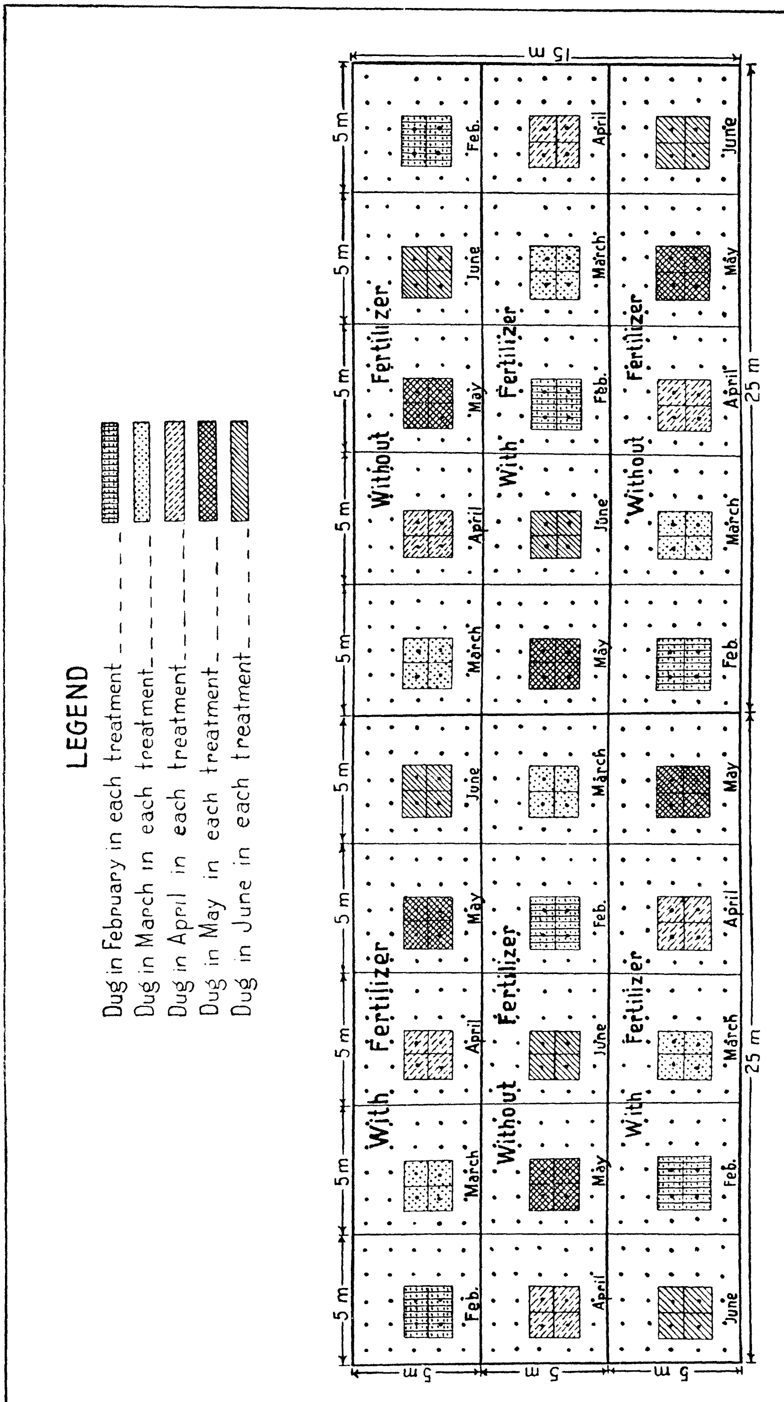

FIG. 5. Showing the arrangement of plots in the experimental field.

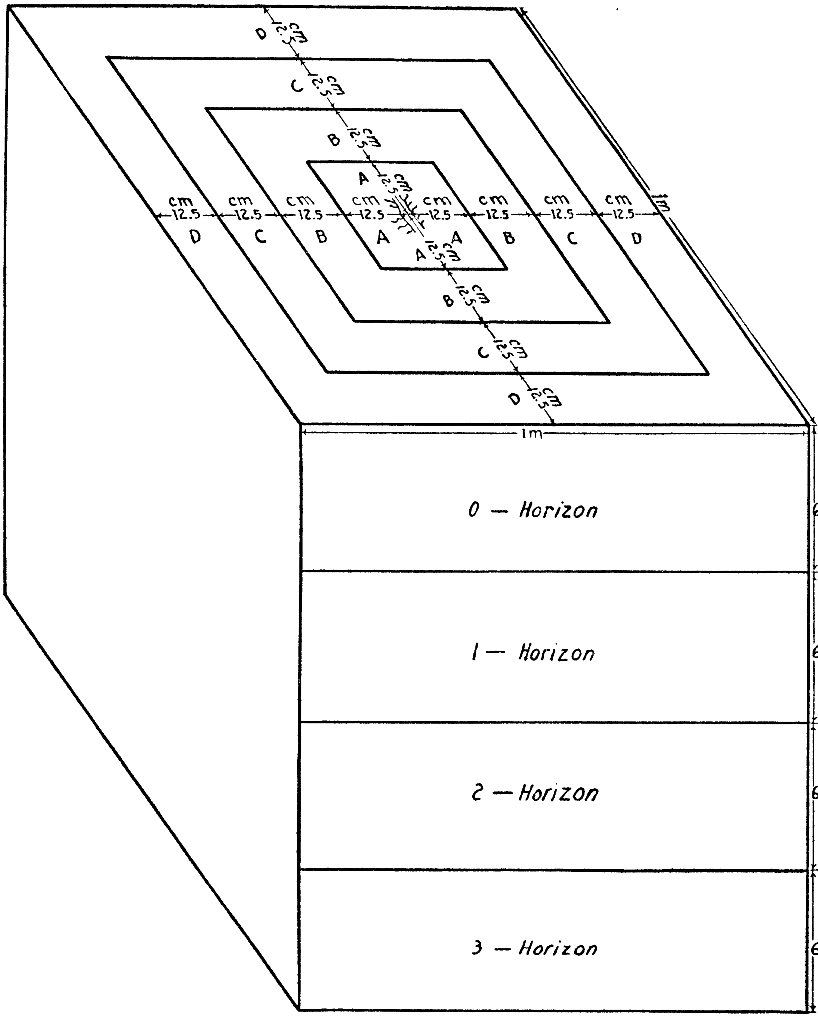

FIG. 6. Showing the different sections of the excavation.

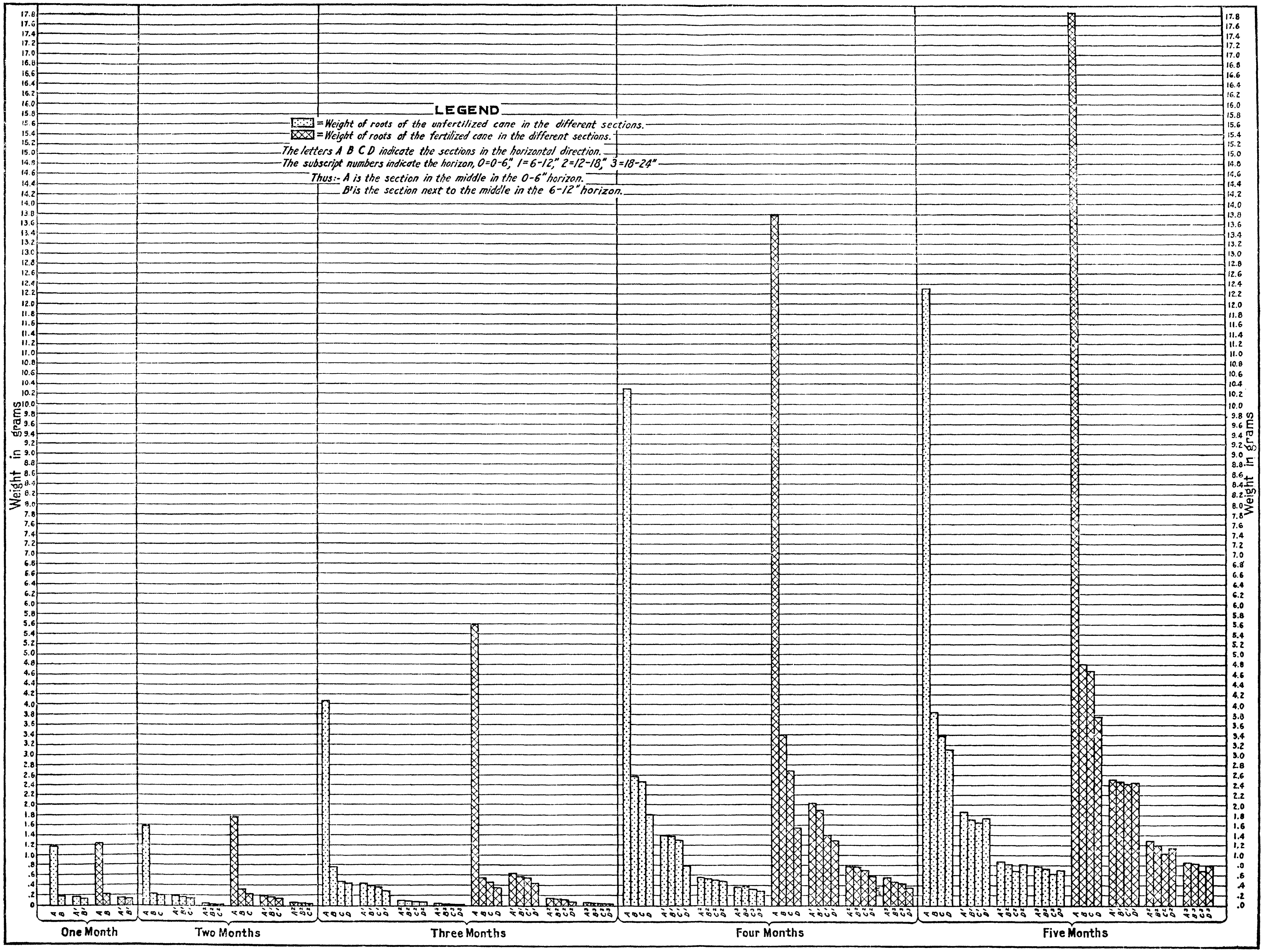

FIG. 7. Showing the weight of roots of both the unfertilized and fertilized stools in the different sections at different levels and ages under field conditions.

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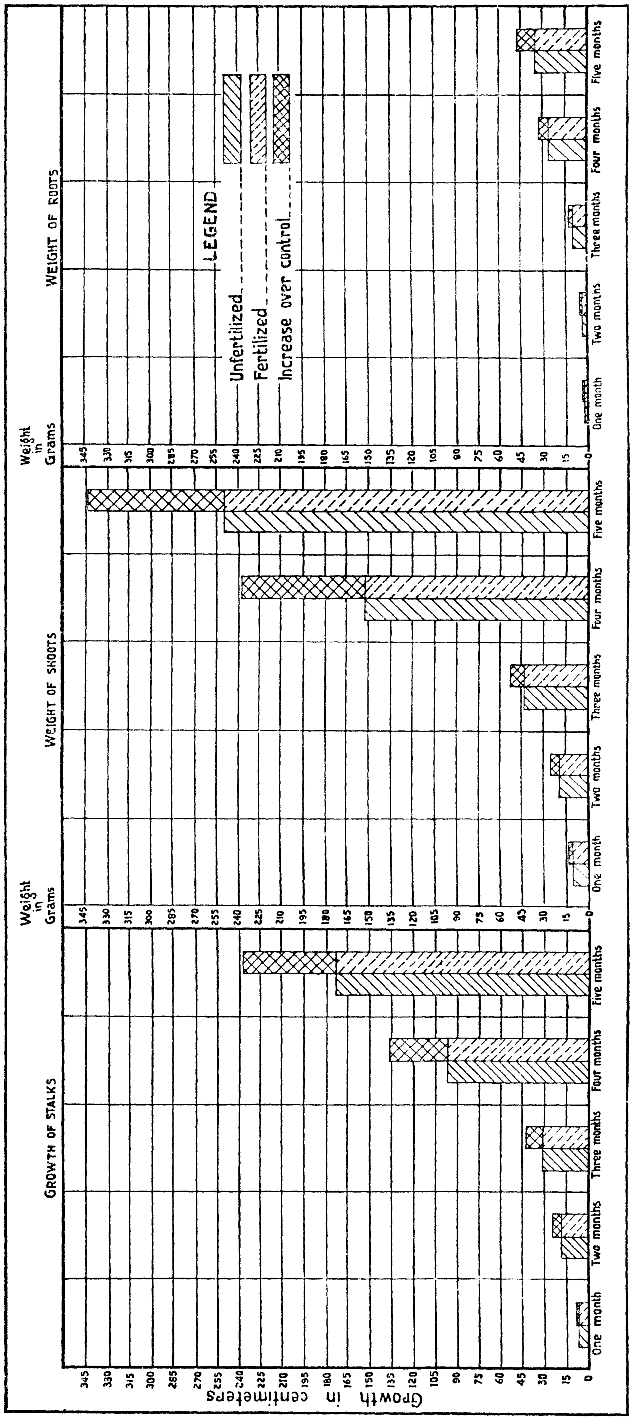

FIG. 8. Comparing the total growth in centimeters, weight of shoots, and weight of roots of both the unfertilized and the fertilized stools at different ages under field conditions.

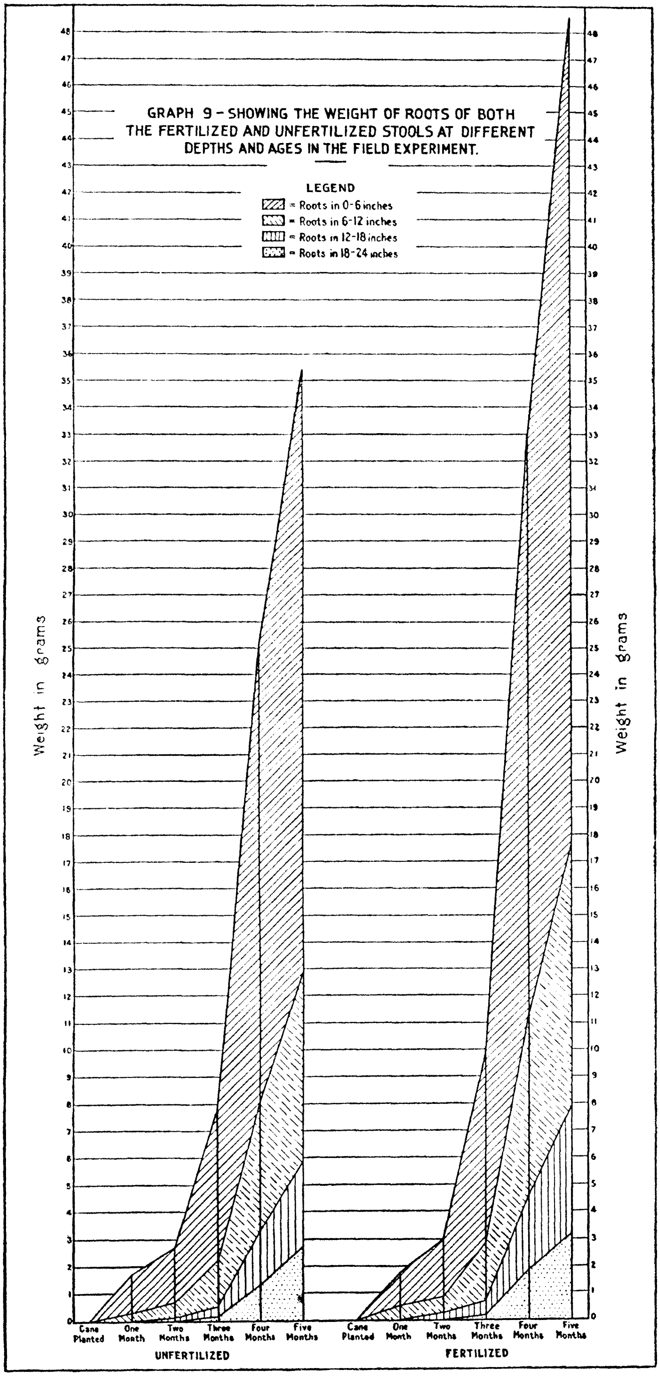

FIG. 9. Showing the weight of roots of both the fertilized and unfertilized stools at different depths and ages in the field experiment.

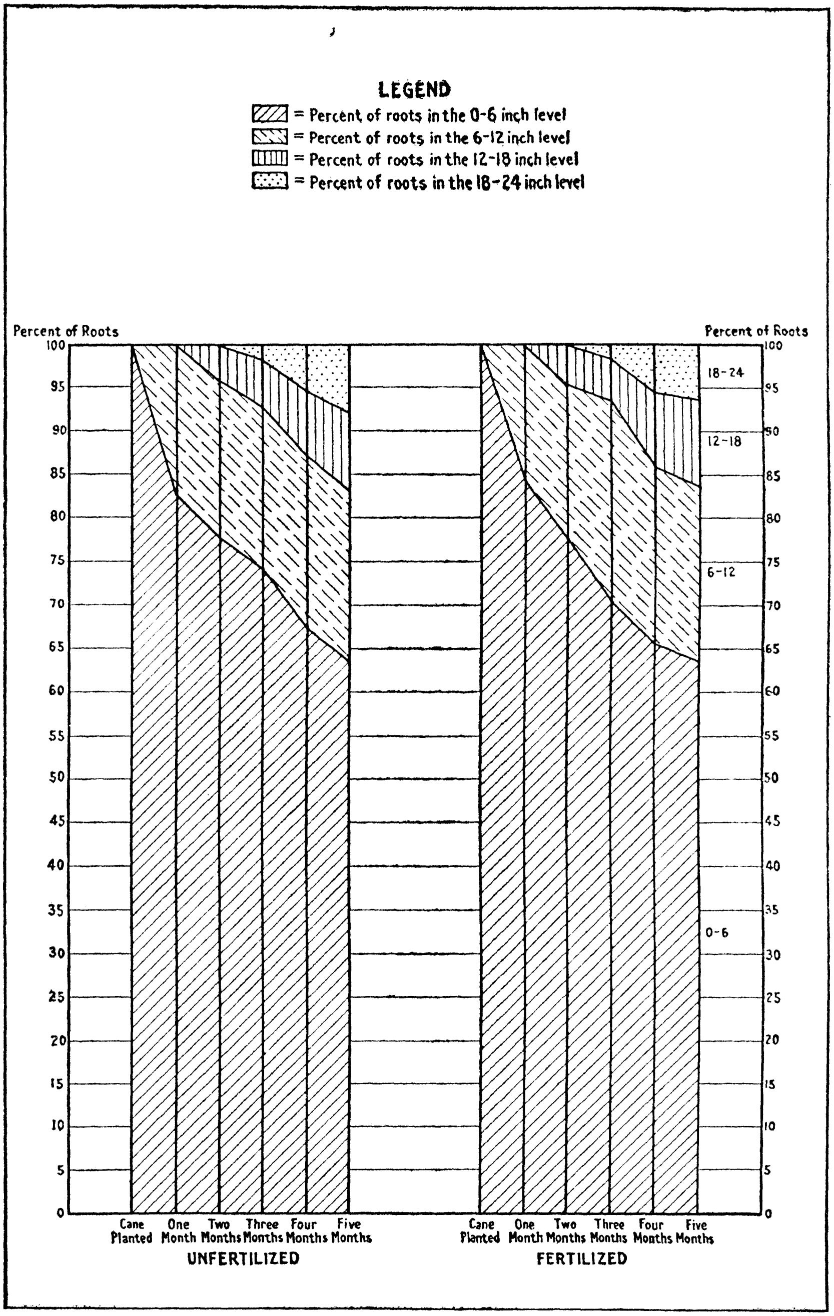

FIG. 10. Showing the distribution in percentages of the total weight of the roots in the different levels of M-1900 under field conditions.

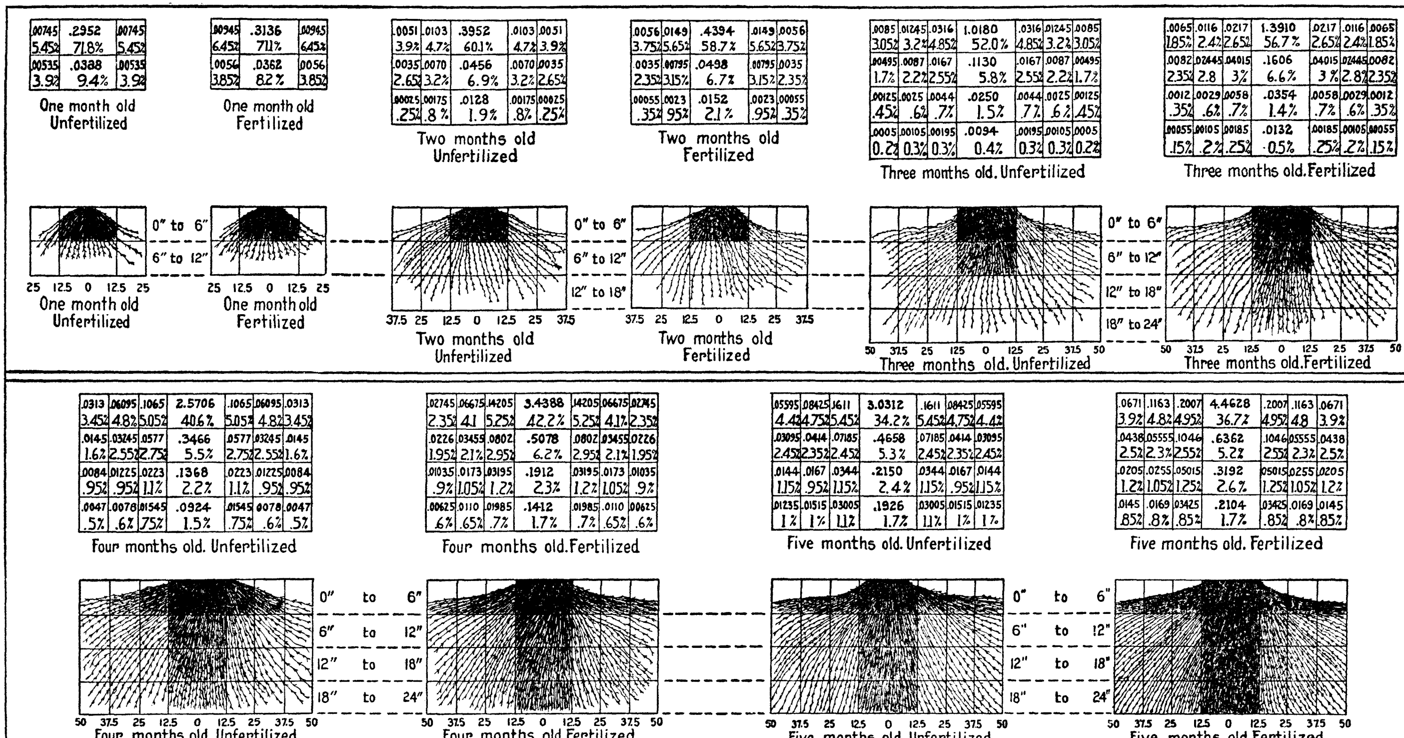

FIG. 11. Showing in figures the weights and percentages of roots in the different sections, and in drawings a section of the root system of M–1900, as reconstructed from its quantitative distribution.

TABLE 1.—*Weights and percentages of roots at different levels and different ages. Modified-box experiment.*

Age.	Spread of root in wire screen.	Different levels.	Unfertilized. Weight of roots in the different compartments.	Unfertilized. Roots in the different levels in per cent of total weight.	Fertilized.[a] Weight of roots in different compartments.	Fertilized.[a] Roots in different compartments in per cent of total weight.
	cm.	*in.*	*g.*		*g.*	
One month after planting (January 19 to February 19).	0–28.5	0–6	1.2474	67.0	1.3400	68.3
	0–28.5	6–12	0.3817	20.5	0.4080	20.8
	0–28.5	6–12	0.2308	12.4	0.2118	10.8
Total			1.8599	99.9	1.9598	99.9
Two months after planting (January 19 to March 22).	0–28	0–6	3.2309	62.8	3.5988	63.6
	0–38	6–12	0.9724	18.9	1.0807	19.1
	0–38	12–18	0.6379	12.4	0.6847	12.1
	0–38	18–24	0.2056	4.0	0.2037	3.6
	0–38	24–30	0.0926	1.8	0.0848	1.5
Total			5.1396	99.9	5.6527	99.9
Three months after planting (January 19 to April 22).	0–38	0–6	9.4600	59.6	11.2762	60.3
	0–38	6–12	2.8253	17.8	3.5343	18.9
	0–38	12–18	2.3015	14.5	2.5806	13.8
	0–38	18–24	0.7936	5.0	0.8976	4.8
	0–38	24–30	0.4762	3.0	0.3927	2.1
Total			15.8566	99.9	18.6814	99.9
Four months after planting (January 19 to May 22).	0–47.5	0–6	24.7018	55.3	31.9265	56.5
	0–47.5	6–12	7.5936	17.0	9.4932	16.8
	0–47.5	12–18	6.7003	15.0	8.5325	15.1
	0–47.5	18–24	2.7247	6.1	2.9383	5.1
	0–47.5	24–30	1.8761	4.2	2.3167	4.1
	0–47.5	30–36	1.0273	2.3	1.2432	2.2
Total			[b] 44.6238	99.9	56.4504	99.9
Five months after planting (January 19 to June 22).	0–57	0–6	51.5172	54.8	69.4535	56.8
	0–57	6–12	16.8276	17.0	21.3985	17.5
	0–57	12–18	12.9732	13.8	16.0183	13.1
	0–57	18–24	5.8285	6.2	6.2361	5.1
	0–57	24–30	4.5124	4.8	5.5024	4.5
	0–57	30–36	2.2562	2.4	3.5460	2.9
Total			93.9151	99.9	122.1548	99.9

[a] Weights are average weights from two boxes.

[b] Weight of only one box. The second box was discarded because the cane was attacked by Fiji.

TABLE 2.—*The average growth per week of the unfertilized and fertilized stools at different ages (modified-box experiment).*

[Measurements in centimeters.]

UNFERTILIZED.[a]

Age.	January 19 planted.	June 26.	February 3 initial measurement.	February 11.	February 19 total growth.	February 26.	March 6.
Months.							
1	0	0	3.0	7.2	10.8	-----	-----
2	0	0	3.1	7.2	11.1	18.2	22.7
3	0	0	2.8	6.5	10.7	16.5	23.1
4	0	0	2.0	7.4	11.8	17.4	23.9
5	0	0	1.8	6.3	11.6	19.0	28.3
Average [b]	0	0	2.5	6.9	11.2	17.8	24.5
FERTILIZED.[a]							
1	0	0	3.7	6.8	12.4	-----	-----
2	0	0	3.7	7.1	12.3	19.4	25.3
3	0	0	3.9	7.2	11.5	18.0	25.1
4	0	0	3.2	7.3	13.4	19.4	26.2
5	0	0	2.1	6.1	11.4	19.6	27.6
Average [b]	0	0	3.3	6.9	12.2	19.1	26.0

UNFERTILIZED.[a]

Age.	March 14.	March 22 total growth.	March 29.	April 6.	April 14.	April 22 total growth.	April 19.
Months.							
1	-----	-----	-----	-----	-----	-----	-----
2	28.6	35.3	-----	-----	-----	-----	-----
3	30.1	38.3	44.2	50.2	56.7	62.7	-----
4	29.0	36.5	43.5	51.5	62.5	70.6	90.6
5	38.3	48.0	59.6	71.0	81.5	92.9	104.7
Average [b]	31.5	39.5	49.1	57.5	66.9	75.4	97.6
FERTILIZED.[a]							
1	-----	-----	-----	-----	-----	-----	-----
2	32.9	40.5	-----	-----	-----	-----	-----
3	32.0	39.5	46.8	53.5	60.4	68.5	-----
4	31.5	40.6	48.2	57.7	66.6	78.4	102.5
5	37.0	49.4	61.4	77.5	90.1	107.2	128.8
Average [b]	33.3	43.5	52.1	62.9	72.3	84.7	115.6

[a] In every month, the average of twelve measurements was taken.

[b] First month, one measurement; second month, average of eight measurements; third month, average of six measurements; fourth month, average of four measurements; fifth month, average of two measurements.

TABLE 2.—*The average growth per week of the unfertilized and fertilized stools at different ages (modified-box experiment)*—Continued.

UNFERTILIZED.[a]

Age.	May 6.	May 14.	May 22 total growth.	May 30.	June 6.	June 14.	June 22 total growth.
Months.							
1	----------	----------	----------	----------	----------	----------	----------
2	----------	----------	----------	----------	----------	----------	----------
3	----------	----------	----------	----------	----------	----------	----------
4	111.8	126.0	161.0	----------	----------	----------	----------
5	126.3	145.3	176.4	200.6	259.7	303.7	364.1
Average [b]	119.0	135.6	168.7	200.6	259.7	303.7	364.1
FERTILIZED.[a]							
1	----------	----------	----------	----------	----------	----------	----------
2	----------	----------	----------	----------	----------	----------	----------
3	----------	----------	----------	----------	----------	----------	----------
4	122.8	165.7	195.2	----------	----------	----------	----------
5	152.9	195.5	223.5	263.4	314.0	370.9	428.5
Average [b]	137.8	180.6	209.4	263.4	314.0	370.9	428.5

[a] In every month, the average of twelve measurements was taken.

[b] First month, one measurement; second month, average of eight measurements; third month, average of six measurements; fourth month, average of four measurements; fifth month, average of two measurements.

TABLE 3.—*Weights per stool of shoots; ratio of tops to roots in the modified-box experiment.*[a]

Treatment.	Average growth of shoots per stool each month.	Average weight of shoots per stool each month.	Average weight of roots per stool each month.	Ratio of tops to roots.
ONE MONTH	*cm.*	*g.*	*g.*	
Fertilized	12.2	14.6985	1.9598	7.5
Unfertilized	11.2	13.3526	1.8599	7.2
Increase over control	1.0	1.3459	0.0999	----------
Do per cent	8.9	10.7	5.3	----------
TWO MONTHS				
Fertilized	43.5	39.0036	5.6527	6.9
Unfertilized	39.5	33.4074	5.1396	6.5
Increase over control	4.0	5.5962	0.5131	----------
Do per cent	10.1	16.7	9.9	----------
THREE MONTHS				
Fertilized	84.7	115.8246	18.6814	6.2
Unfertilized	75.4	88.7969	15.8566	5.6
Increase over control	9.3	27.0277	2.8248	----------
Do per cent	12.3	30.4	17.8	----------
FOUR MONTHS				
Fertilized	209.4	327.4123	56.4504	5.8
Unfertilized	168.7	240.9685	44.6238	5.4
Increase over control	40.4	86.4438	11.8266	----------
Do per cent	23.9	35.8	26.5	----------
FIVE MONTHS				
Fertilized	428.5	696.2823	122.1548	5.7
Unfertilized	364.2	497.7500	93.9151	5.3
Increase over control	64.3	198.5323	28.2397	----------
Do per cent	17.6	39.8	30.0	----------

[a] Fifteen grams per point.

TABLE 4.—*Weights and percentages of roots of unfertilized and fertilized stools at different ages and different sections in the field experiments.*

Age.	Section.	Lateral spread.	Depth.	Unfertilized.				Fertilized.			
				Average weight of roots.[a]	Total weight of roots at different depths.	Roots in each section per cent total roots.	Roots at different depths per cent total roots.	Average weight of roots.[a]	Total weight of roots at different depths.	Roots in each section per cent total roots.	Roots at different depths per cent total roots.
		cm.	*in.*	*g.*				*g.*			
One month after planting	A_1	0–12.5	0–6	1.1813		71.8		1.2550		71.1	
	B	12.5–25	0–6	0.1796	1.3609	10.9	82.7	0.2276	1.4826	12.9	84.0
	A_1	0–12.5	6–12	0.1555		9.4		0.1452		8.2	
	B_1	12.5–25	6–12	0.1266	0.2841	7.8	17.2	0.1355	0.2807	7.7	15.9
Total				1.6450	1.6450	99.9	99.9	1.7633	1.7633	99.9	99.9
Two months after planting	A	0–12.5	0–6	1.5811		60.1		1.7580		58.7	
	B	12.5–25	0–6	0.2477		9.4		0.3383		11.3	
	C	25–37.5	0–6	0.2047	2.0335	7.8	77.3	0.2255	2.3218	7.5	77.6
	A_1	0–12.5	6–12	0.1830		6.9		0.1995		6.7	
	B_1	12.5–5–25	6–12	0.1680		6.4		0.1913		6.3	
	C_1	25–37.5	6–12	0.1404	0.4914	5.3	18.6	0.1400	0.5308	4.7	17.7
	A_2	0–12.5	12–18	0.0513		1.9		0.0615		2.1	
	B_2	12.5–25	12–18	0.0428		1.6		0.0556		1.9	
	C_2	25–37.5	12–18	0.0116	0.1057	0.5	4.0	0.0236	0.1407	0.7	4.6
Total				2.6306	2.6306	99.9	99.9	2.9933	2.9933	99.9	99.9
Three months after planting	A	0–12.5	0–6	4.0721		52.0		5.5647		56.7	
	B	12.5–25	0–6	0.7592		9.7		0.5209		5.3	
	C	25–37.5	0–6	0.4984		6.4		0.4713		4.8	
	D	37.5–50	0–6	0.4773	5.8050	6.1	74.2	0.3655	6.9224	3.7	70.6
	A_1	0–12.5	6–12	0.4526		5.8		0.6428		6.6	
	B_1	12.5–25	6–12	0.4014		5.1		0.5879		6.0	

[a] Twelve stools were averaged.

TABLE 4.—*Weights and percentages of stools of unfertilized and fertilized stools at different ages and different sections in the field experiments*—Continued.

Age	Section.	Lateral spread.	Depth.	Unfertilized. Average weight of roots.[a]	Unfertilized. Total weight of roots at different depths.	Unfertilized. Roots in each section per cent total roots.	Unfertilized. Roots at different depths per cent total roots.	Fertilized. Average weight of roots.[a]	Fertilized. Total weight of roots at different depths.	Fertilized. Roots in each section per cent total roots.	Fertilized. Roots at different depths per cent total roots.
		cm.	*in.*	*g.*				*g.*			
Three months after planting	C_1	25-37.5	6-12	0.3481		4.4		0.5475		5.6	
	D_1	37.5-50	6-12	0.2774	1.4795	3.4	18.7	0.4599	2.2382	4.7	22.8
	A_2	0-12.5	12-18	0.1003		1.5		0.1418		1.4	
	B_2	12.5-25	12-18	0.1064		1.4		0.1398		1.4	
	C_2	25-37.5	12-18	0.1003		1.2		0.1162		1.2	
	D_2	37.5-50	12-18	0.0707	0.3777	0.9	5.1	0.0679	0.4657	0.7	4.8
	A_3	0-12.5	18-24	0.0377		0.4		0.0531		0.5	
	B_3	12.5-25	18-24	0.0475		0.6		0.0453		0.3	
	C_3	25-37.5	18-24	0.0433		0.6		0.0433		0.4	
	D_3	37.5-50	18-24	0.0291	0.1576	0.4	1.9	0.0550	0.1747	0.3	1.7
Total				7.8198	7.8198	99.9	99.9	9.8010	9.8010	99.9	99.9
Four months after planting	A	0-12.5	0-6	10.2828		40.6		13.7557		42.2	
	B	12.5-25	0-6	2.5565		10.1		3.4102		10.5	
	C	25-37.5	0-6	2.4394		9.6		2.6716		8.2	
	D	37.5-50	0-6	1.7531	17.0318	6.9	67.3	1.5376	21.3751	4.7	65.5
	A_1	0-12.5	6-12	1.3871		5.5		2.0317		6.2	
	B_1	12.5-25	6-12	1.3856		5.5		1.9259		5.9	
	C_1	25-37.5	6-12	1.2996		5.1		1.3839		4.2	
	D_1	37.5-50	6-12	0.8120	4.8845	3.2	19.3	1.2668	6.6083	3.9	20.3
	A_2	0-12.5	12-18	0.5479		2.2		0.7652		2.3	
	B_2	12.5-25	12-18	0.5356		2.2		0.7669		2.4	
	C_2	25-37.5	12-18	0.4917		1.9		0.6926		2.1	

Four months after planting	D_2	37.5–50	12–18	0.4729	2.0481	1.9	8.1	0.5806	2.8053	1.8	8.6
	A_3	0–12.5	18–24	0.3698		1.5		0.5654		1.7	
	B_3	12.5–25	18–24	0.3718		1.5		0.4769		1.4	
	C_3	25–37.5	18–24	0.3129		1.2		0.4408		1.3	
	D_3	37.5–50	18–24	0.2641	1.3186	1.0	5.2	0.3517	1.8548	1.2	5.6
Total				25.2828	26.2828	99.9	99.9	32.6235	32.6235	100.0	100.0
Five months after planting	A	0–12.5	0–6	12.1254		34.2		17.8516		36.7	
	B	12.5–25	0–6	3.8668		10.9		4.8170		9.9	
	C	25–37.5	0–6	3.3713		9.5		4.6535		9.6	
	D	37.5–50	0–6	3.1334	22.4969	8.8	63.5	3.7593	31.0814	7.8	63.9
	A_1	0–12.5	6–12	1.8632		5.3		2.5455		5.2	
	B_1	12.5–25	6–12	1.7244		4.9		2.5106		5.1	
	C_1	25–37.5	6–12	1.6569		4.7		2.2226		4.6	
	D_1	37.5–50	6–12	1.7345	6.9790	4.9	19.7	2.4534	9.7321	5.0	20.0
	A_2	0–12.5	12–18	0.8604		2.4		1.2772		2.6	
	B_2	12.5–25	12–18	0.8260		2.3		1.2036		2.5	
	C_2	25–37.5	12–18	0.6642		1.9		1.0289		2.1	
	D_2	37.5–50	12–18	0.8071	3.1577	2.3	8.9	1.1481	4.6578	2.4	9.6
	A_3	0–12.5	18–24	0.7707		1.7		0.8417		1.7	
	B_3	12.5–25	18–24	0.7217		2.2		0.8227		1.7	
	C_3	25–37.5	18–24	0.6070		2.0		0.6772		1.6	
	D_3	37.5–50	18–24	0.6933	2.7927	2.0	7.9	0.8121	3.1537	1.7	6.5
Total				35.4263	35.4263	100.0	100.0	48.6250	48.6250	99.9	100.0

[a] Twelve stools were averaged.

TABLE 4a.—*Densities in grams of roots per block for different ages, both for the unfertilized and fertilized stools. Densities (grams per hectare).*[a]

Age.	Block.	Density.	
		Unfertilized.	Fertilized.
One month after planting	A	0.2943	0.3136
	B	0.01496	0.0189
	A_1	0.0398	0.0362
	B_1	0.01071	0.0112
Two months after planting	A	0.3952	0.4394
	B	0.02065	0.0298
	C	0.01024	0.0112
	A_1	0.0457	0.0498
	B_1	0.0140	0.0159
	C_1	0.00702	0.0070
	A_2	0.0129	0.0152
	B_2	0.0035	0.0046
	C_2	0.0005	0.0011
Three months after planting	A	1.0180	1.3910
	B	0.0632	0.0434
	C	0.0240	0.0232
	D	0.0170	0.0130
	A_1	0.1130	0.1606
	B_1	0.0334	0.0489
	C_1	0.0174	0.0273
	D_1	0.0099	0.0164
	A_2	0.0250	0.0354
	B_2	0.0088	0.0116
	C_2	0.0050	0.0058
	D_2	0.0025	0.0024
	A_3	0.0094	0.0132
	B_3	0.0039	0.0037
	C_3	0.0021	0.0021
	D_3	0.0010	0.0011
Four months after planting	A	2.5700	3.4398
	B	0.2130	0.2841
	C	0.1219	0.1336
	D	0.0626	0.0549
	A_1	0.3467	0.5078
	B_1	0.11546	0.1604
	C_1	0.06498	0.0691
	D_1	0.0290	0.0452
	A_2	0.1369	0.1913
	B_2	0.04463	0.0639
	C_2	0.0245	0.0346
	D_2	0.0168	0.0207
	A_3	0.0924	0.1413
	B_3	0.0309	0.0397
	C_3	0.0156	0.0220
	D_3	0.0094	0.0125

[a] The densities given in this table are calculated as follows: The weights of roots for all the A-sections were divided by 4, those for the B's by 12, those for the C's by 20, and those for the D's by 28. Those are the numbers of blocks of 12.5 centimeters and 6 inches contained in those sections in the different horizons.

TABLE 4*a*.—*Densities in grams of roots per block for different ages, both for the unfertilized and fertilized stools. Densities (grams per hectare)*—Continued.

Age.	Block.	Density. Unfertilized.	Density. Fertilized.
Five months after planting	A	3.0312	4.4629
	B	0.3222	0.4014
	C	0.1685	0.2326
	D	0.1119	0.1342
	A_1	0.4658	0.6362
	B_1	0.1437	0.2092
	C_1	0.0828	0.1111
	D_1	0.0619	0.0876
	A_2	0.2050	0.3193
	B_2	0.0688	0.1003
	C_2	0.0334	0.0514
	D_2	0.0288	0.0410
	A_3	0.1926	0.0104
	B_3	0.0601	0.0685
	C_3	0.0603	0.0338
	D_3	0.0247	0.0290

TABLE 5.—*Average growth per week of the unfertilized and fertilized stools at different ages in the field experiments.*

UNFERTILIZED.[a]

Age.	January 19 planted.	January 26.	February 3 initial measurements.	February 11.	February 19 total growth.	February 26.	March 6.
Months.							
1	0	0	2.9	6.6	9.5		
2	0	0	3.8	6.0	9.3	11.4	13.5
3	0	0	3.5	5.6	8.6	10.8	13.3
4	0	0	2.5	5.3	8.9	11.1	13.5
5	0	0	2.5	3.8	9.0	10.8	12.6
Average	0	0	3.0	3.6	[b]8.8	11.0	13.2
FERTILIZED.[a]							
1	0	0	3.1	6.1	9.0		
2	0	0	3.6	7.0	10.8	13.1	15.8
3	0	0	2.9	6.3	10.6	12.3	17.0
4	0	0	2.9	6.1	9.8	14.1	16.0
5	0	0	3.3	6.5	9.5	12.9	17.2
Average	0	0	3.2	6.4	[b]9.9	13.1	16.5

[a] For every month, the average of twelve measurements was taken.
[b] Average of sixty measurements.

TABLE 5.—*Average growth per week of the unfertilized and fertilized stools at different ages in the field experiments*—Continued.

UNFERTILIZED.[a]

Age.	March 14.	March 22 total growth.	March 29.	April 6.	April 14.	April 22 total growth.	April 29.
Months.							
1							
2	15.7	18.2					
3	16.0	18.8	20.6	22.5	24.5	29.7	
4	15.9	19.4	21.7	24.3	26.9	32.3	44.7
5	14.8	17.1	19.7	23.3	25.3	31.1	44.9
Average	15.6	[c] 18.3	20.6	23.3	25.5	[d] 31.0	44.8
FERTILIZED.[a]							
1							
2	18.7	21.4					
3	20.8	25.4	30.0	31.0	41.8	46.0	
4	20.4	25.9	28.9	30.0	37.4	43.4	60.6
5	21.0	26.1	29.2	32.0	35.2	42.2	59.1
Average	20.2	[c] 24.7	29.3	31.0	88.1	[d] 43.3	59.8

UNFERTILIZED.[a]

Age.	May 6.	May 14.	May 22 total growth.	May 30.	June 6.	June 14.	June 22 total growth.
Months.							
1							
2							
3							
4	53.4	74.7	93.5				
5	57.2	79.2	98.8	117.4	135.6	153.2	174.9
Average	55.3	76.9	[e] 96.1	117.4	135.6	153.2	[f] 174.9
FERTILIZED.[a]							
1							
2							
3							
4	73.3	107.6	140.8				
5	77.1	110.0	130.5	155.6	170.9	205.7	239.3
Average	75.2	108.8	[e] 135.6	155.6	170.9	205.7	[f] 239.3

[a] For every month, the average of twelve measurements was taken.
[c] Average of forty-eight measurements.
[d] Average of thirty-six measurements.
[e] Average of twenty-four measurements.
[f] Average of twelve measurements.

TABLE 6.—*Weights per stool of shoots and roots and the ratio of tops to roots in the field experiment.*

Treatment and age.	Average growth of shoots per stool.	Average weight of shoots per stool each month.	Average weight of roots per stool each month.	Ratio of tops to roots.
ONE MONTH	*cm.*	*g.*	*g.*	
Fertilized	9.9	13.9300	1.7833	7.9
Unfertilized	8.8	12.6665	1.6450	7.7
Increase over control	1.1	1.2635	0.1183	----------
Do per cent	12.5	9.9	7.2	----------
TWO MONTHS				
Fertilized	24.7	22.1504	2.9933	7.4
Unfertilized	18.3	18.4842	2.6406	7.0
Increase over control	6.4	3.6662	0.3527	----------
Do per cent	34.9	19.8	13.4	----------
THREE MONTHS				
Fertilized	43.3	67.6269	9.6010	6.9
Unfertilized	31.0	50.0473	7.8199	6.4
Increase over control	12.3	17.5796	1.9811	----------
Do per cent	25.3	35.12	39.6	----------
FOUR MONTHS				
Fertilized	135.6	205.5280	32.6235	6.3
Unfertilized	96.1	151.6992	25.2832	6.0
Increase over control	39.5	53.8288	7.3403	----------
Do per cent	41.1	35.48	29.0	----------
FIVE MONTHS				
Fertilized	239.3	311.2217	48.6284	6.4
Unfertilized	174.9	216.1004	35.4263	6.1
Increase over control	64.4	95.1213	13.4263	----------
Do per cent	36.9	44.00	37.2	----------

DISCUSSION OF THE RESULTS

The box experiments.—The percentages of roots in the different levels shown by Table 1 are in general in agreement with the results obtained by other investigators, in that large percentages of the roots of the cane are on the topmost surface of the soil. However, as the roots develop there is a rapid increase in the root masses in all levels, particularly the uppermost three layers. As is to be expected, as the roots grow deeper, the percentages in the topmost 6-inch layer decrease.

Comparing the fertilized with the unfertilized stools, it is seen that the root masses in practically all the layers and during

the whole period of this experiment have been higher for the fertilized than for the unfertilized stools.

Table 2 shows the growth measurements of the fertilized and unfertilized stools. The figures in Table 2 are visualized in fig. 3. It is seen here that the rate of growth of the fertilized stools is consistently greater than that of the unfertilized, and that there is a parallelism between the greater rate of growth of both the roots and the shoots of fertilized stools as compared with that of the unfertilized. We may say, therefore, that the fertilizer accelerated the growth of both the roots and the shoots of the young canes. A corresponding parallelism exists between the accelerated growth of the roots and shoots of fertilized cane and between the weights of roots and weights of the stalks. This is shown by Table 3. Table 3 also gives the ratio for shoot to root weights. The ratios for the fertilized stools are consistently higher than those for the unfertilized. This shows that the acceleration given by the fertilizer has a more pronounced effect on the shoots than on the roots.

Another noteworthy fact recorded in Table 3 is that as the cane grows, from planting up to five months, the ratio of tops to roots decreases, showing a more rapid increase in the weights of the roots during this period. This is true of both the fertilized and the unfertilized stools, and is evidently a habit of the cane plant. It is also to be noted that the drop in the ratio of tops to roots is not along a straight line but along a parabolic curve, the ratio probably falling between 5.5 and 5.8. What the ratio of roots to shoots is in mature cane only further experiments will show. The ratio will most likely again increase, and greatly pass the ratio at the start, as the cane continues its development.

The root system of Mauritius 1900 grown in the modified boxes is shown by the series of photographs given in Plates 1 to 5. Plate 1 is for a 1-month cane, Plate 2, for a 2-month cane, Plate 3, for a 3-month cane, Plate 4, for a 4-month cane, and Plate 5, for a 5-month cane. In general, the pictures show a greater mass of roots for the fertilized than for the unfertilized, and a general tendency for the roots to grow downward, in the majority of cases almost vertically.

The field experiment.—Table 4 shows the results of excavation of the stools in the field experiment. These results are visualized in figs. 7 and 11.

In general, the distribution of the roots in the field experiment offers the same picture as that in the box experiment.

The root system consists of stems growing from the foot of the cane and radiating in all directions but mostly downward.

Dividing the space occupied by the roots into blocks 12.5 by 12.5 by 15 centimeters and dividing the weight per section by the number of blocks in each section, we obtain figures which we may designate as densities of the root in each block. By referring to Table 4*a* it can be seen that the densities become less and less as the distances from the foot become greater. The greatest densities are in the A to A–3 sections where by far the greatest masses of roots are found. Follow these in the B, C, D sections in the order named. It is also to be noted that the density in the A-section for the 5-month-old cane is about twenty times that in the B and about seven times that in the A_1.

Comparing the unfertilized with the fertilized it is seen that the fertilizer increased the root densities in all blocks but that the greatest increase is in the $A–A_1$ zone, where the fertilizer was applied.

Table 5 gives the growth measurements for both the fertilized and unfertilized stools of the field experiment. As in the case of the box experiment the fertilizer is seen here to have greatly accelerated the growth of the cane.

Table 6 is a comparison of the rate of growth, weight of shoots, weight of roots, and ratio of shoots to roots, both for the unfertilized and the fertilized stools. As in the box experiments the ratios of top to roots are consistently greater for the fertilized than for the unfertilized and decrease with the age of the cane up to 5 months. The same explanation is offered that was given in the discussion of the box experiment. It is to be noted, however, that the ratios in the field experiment, both for the fertilized and the unfertilized canes, are consistently higher than those for the box experiment.

In spite of the fact that the soil in the field experiment is richer than that in the box experiment, if we may follow the general criterion that the hillocks have poorer soil than the lower flat ground, the corresponding weights of both the roots and shoots, both fertilized and unfertilized, as well as the rate of growth of the cane in the box experiment are consistently higher than in the field experiment. This difference in favor of the poorer soil is undoubtedly due to the better aëration, induced by the mechanical disturbances brought about in digging the holes, and to the watering of the soil in the boxes when returning the different layers of soil to their respective places. It is also

to be noted that in the box experiment the penetration of the roots to the lower levels is greater than in the field experiment. In other words we may have here evidence of the good effect of subsoiling in inducing downward development of the root system. Also, corresponding to the greater weight of roots in the box experiments, there is increased weight of shoots, amounting to more than 100 per cent of the weight of the shoots in the field experiment, clearly showing a correlation between shoot weights and root weights during the early life of the cane plant.

Practical significance of the results obtained in these studies.—The field study reported here has given us a much better picture of the root system of Mauritius variety of sugar cane, and presumably its habit is shared by the other noble varieties. The influence of aëration and fertilization is to increase the mass and distribution of the roots, but the habit of concentrating the roots in a zone below the foot, where the density of the roots is many times that of the outer zone persists throughout. The A zone, where some 80 per cent of the roots are found, is confined to the space 12.5 centimeters around the foot and to a depth of 24 inches from the surface of the soil. This must, therefore, be the zone where fertilizer should be applied, and which should be reached by the irrigation water (where irrigation is practiced).

Where to apply the fertilizer is shown in fig. 12. The best place to apply the fertilizer is indicated by the arrow. As in

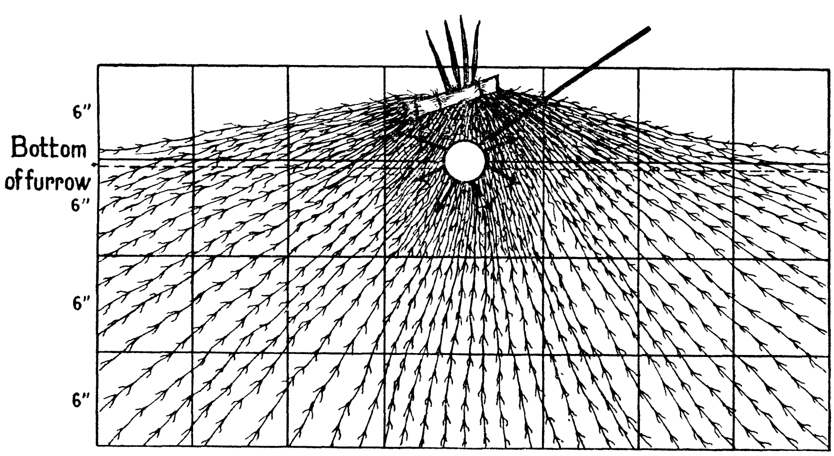

FIG. 12. Showing the most desirable place to apply the fertilizer. The long arrow indicates where the heap of fertilizer must be placed at the time of planting. If a little water is poured over it, the dissolved fertilizer will diffuse downward and spread within the space that will be occupied by the greatest mass of active roots as indicated by the small arrows.

Luzon we have good reasons for applying the fertilizer at the time of planting, the detail of application should be as follows:

1. Make deep furrows for planting.
2. Place the fertilizer deep in the furrow, approximately where the points will be planted, mix it with the soil, and pour a little water on it to carry the fertilizer down, as indicated by the small arrows in fig. 12. Then place the point in such a way that it occupies just the space above where the fertilizer was placed.

Judging from the results of this year's field tests on the methods of applying fertilizer, which we have reported in another paper, one cannot be too careful in the application of the fertilizer. A great deal may be lost with the wrong application. Even if the present cost of application were doubled, the gains to be obtained from the proper application will compensate such an additional expense from ten to twenty times over.

A second corollary to the results of these root studies is in the method of cultivation. The distribution of the roots of the cane is such that plowing within 5 inches from the foot of the cane is to be decried. Cultivators that penetrate more than 3 inches must be passed some 6 inches away from the stools. When such cultivators are thus used, they will destroy insignificant amounts of root. On the other hand, if a plow is passed to within 5 inches of the foot and to a depth of 6 inches, as much as 7 per cent of the roots may be cut off, and such pruning will undoubtedly result in the stunting of the cane. The difference in root masses between the 5-month-old unfertilized and the 5-month-old fertilized cane is around 37.2 per cent of the weight of roots of the unfertilized cane. This difference in root mass is responsible for a difference of 44 per cent in the weight of the tops in favor of the fertilized canes. Pruning 7 per cent of the roots of the cane, unless the variety has great recuperative power, cannot but have a retarding effect on the rate of growth of the cane.

The present studies were limited to five months because the junior author who executed them had only that much time to spend at the station, since at the end of that period he had to return to college. So it was decided to limit our preliminary studies to the period of cultivation of the cane which is the critical period of growth, and the time when the size of the crop may be greatly affected by proper or improper cultivation methods. After five months, in June, the cane has usually closed up, and receives no further attention until harvest time. In other

words, from the point of view of human influence on the size of the crop, this should be considered the most important period. After this period, the fate of the cane is largely dependent on the monsoons. However, the results obtained in this preliminary work encourages us to plan more extensive studies to include other varieties, and the whole period of the life of the cane plant.

A suggested method of studying roots in relation to cultural methods is to divide the root zones as indicated in fig. 13.

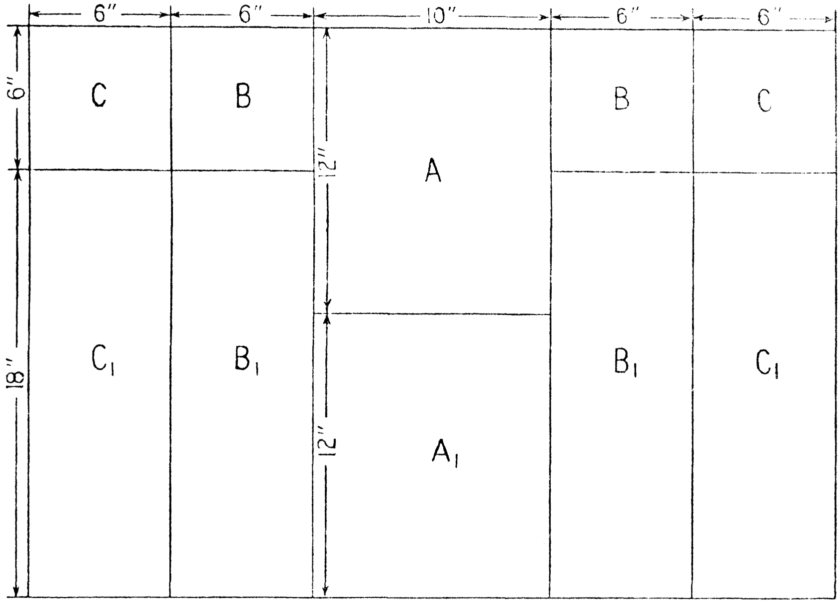

FIG. 13. Showing the proposed zones to be excavated in studying the root systems of different varieties and the effect of cultural treatments on their roots development.

Standard figures for five-month canes may be established for the different zones for different soil conditions and varieties. If in excavations made in commercial plantings it is discovered that the root mass in any of these zones is below standard, reason for it must be sought.

SUMMARY OF CONCLUSIONS

1. Two series of studies on the root and shoot development of Mauritius 1900 variety of cane were conducted. In one, a modified-box method was used, in which wire netting held on frames nailed on posts was placed in holes in the ground and

the subsoil and soil layers were replaced in their original condition. In the other, the cane was planted in replicated plots, and arranged in *dama-dama*. Two treatments were used—with and without fertilizer.

2. In both studies it was found that increased shoot development corresponded to increased root development, without exception.

3. The roots of the cane develop faster than the shoot during the first months of its growth. This is in line with the old conception that plants first develop a good root system before shoot development will take place actively.

4. Aëration of the subsoil favors the formation of greater masses of roots in the lower levels.

5. The cane plant tends to concentrate its mass of roots within a zone about 5 inches on each side and 12 to 18 inches below the foot of the cane. This is the zone where fertilizer must be applied.

6. Fertilizer increased the masses of roots through the whole system and not only in the zone where the fertilizer was applied.

7. The suggested method of application is to place the fertilizer in the furrow just before planting in an oval of about 6 inches, mixing it thoroughly with the soil and pouring water over it to carry it down to the lower levels. The point should be planted over this oval.

8. Further studies, using the method followed in this paper and including other varieties and the whole period of growth of the cane plant, are recommended.

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ILLUSTRATIONS

Root Systems of Mauritius 1900 Grown in Modified boxes.

Plate 1. A 1-month cane.
2. A 2-month cane.
3. A 3-month cane.
4. A 4-month cane.
5. A 5-month cane.

TEXT FIGURES

Fig. 1. Graph showing the arrangement of the modified-box experiment.
2. Graph showing the weight of roots in the different horizons and at different ages both for the fertilized and unfertilized cane in the box experiment.
3. Graph comparing growth, weight of shoots, and weight of roots of the fertilized and the unfertilized stools in the modified-box experiment.
4. Graph showing the distribution in percentages of the total weight of the roots in the different horizons of M–1900 in the modified-box experiment.
5. Graph showing the arrangement of plots in the experimental field.
6. Graph showing the different sections of the excavation.
7. Graph showing the weight of roots of both the unfertilized and fertilized stools in the different sections at different levels and ages under field conditions.
8. Graph comparing the total growth in centimeters, weight of shoots, and weight of roots of both the unfertilized and the fertilized stools at different ages under field conditions.
9. Graph showing the weight of roots of both the fertilized and unfertilized stools at different depths and ages in the field experiment.
10. Graph showing the distribution in percentages of the total weight of the roots in the different levels of M–1900 under field conditions.
11. Graph showing in figures the weights and percentages of roots in the different sections, and in drawings a section of the root system of M–1900, as reconstructed from its quantitative distribution.
12. Graph showing the most desirable place to apply the fertilizer. The long arrow indicates where the heap of fertilizer must be placed at the time of planting. If a little water is poured over it, the dissolved fertilizer will diffuse downward and spread within the space that will be occupied by the greatest mass of active roots as indicated by the small arrows.
13. Graph showing the proposed zones to be excavated in studying the root systems of different varieties and the effect of cultural treatments on their root development.

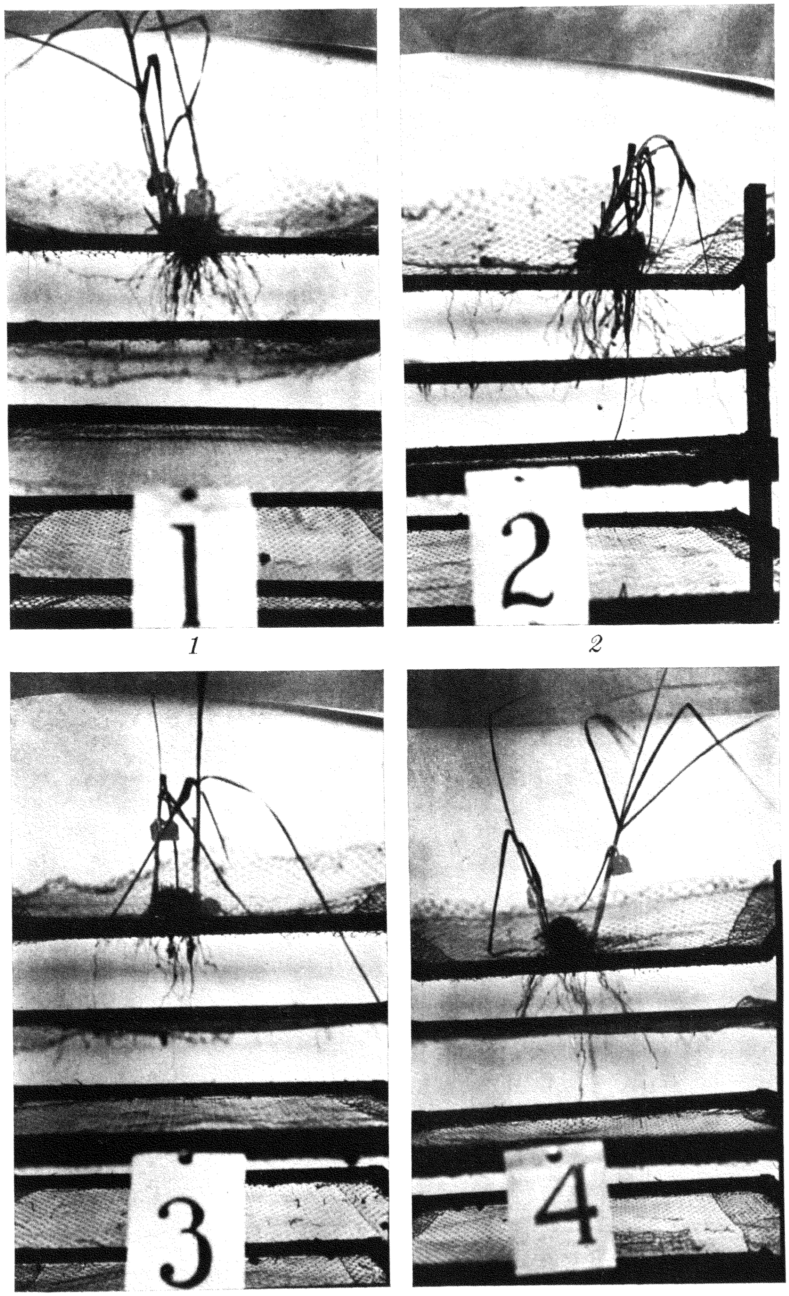

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PLATE 1.

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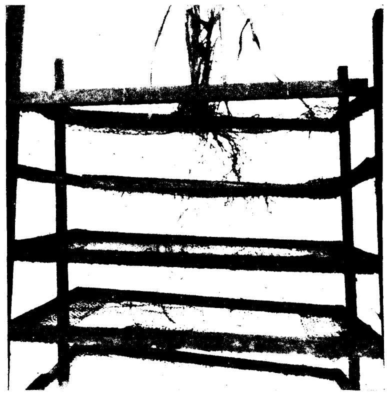

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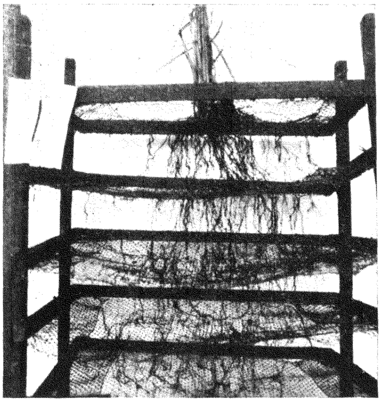
PLATE 2.



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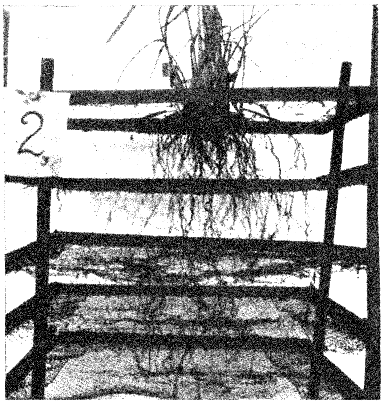

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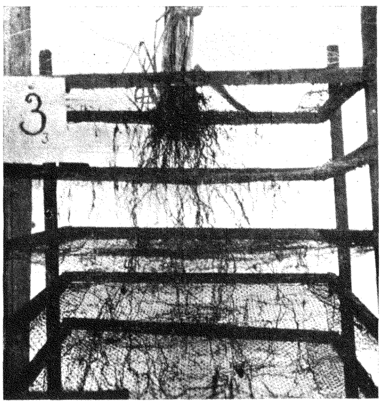

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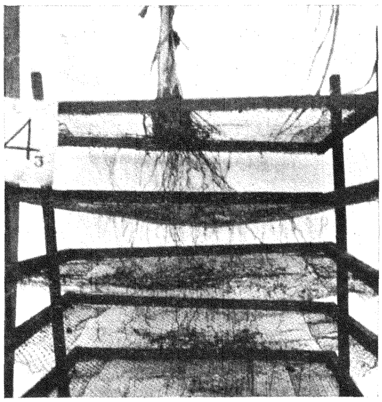

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PLATE 3.

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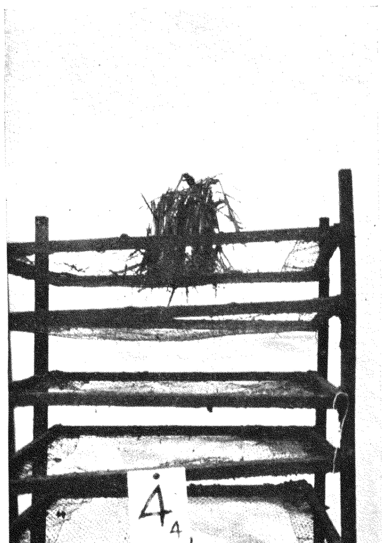

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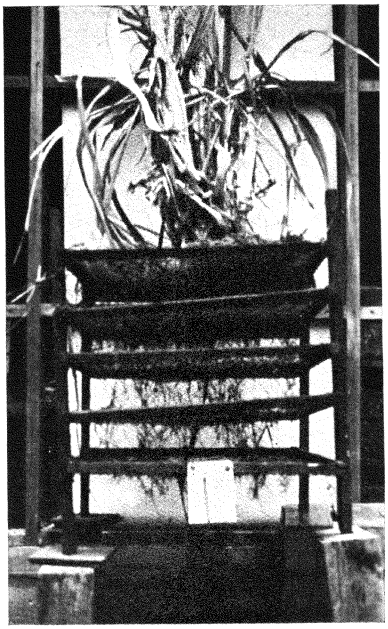
PLATE 4.



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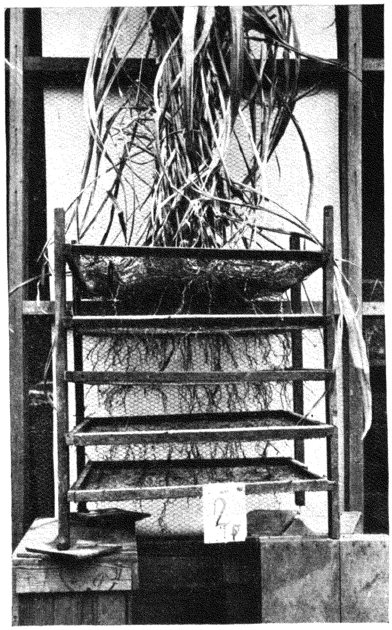

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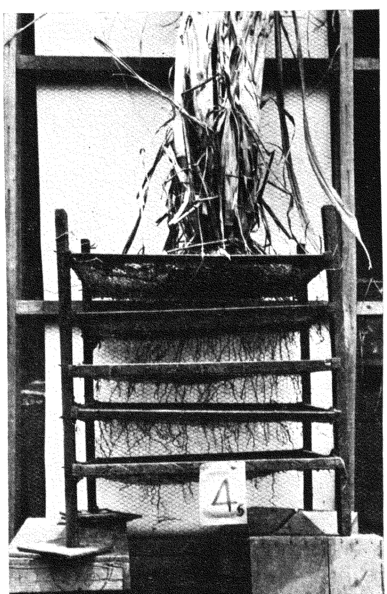

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PLATE 5.

THE OCCLUSION OF LEAD AND COPPER IN NONFERROUS ALLOYS BY METASTANNIC AND METANTIMONIC ACIDS

By SALVADOR DEL MUNDO

Chemist, Division of Inorganic Chemistry, Bureau of Science, Manila

In the analysis of alloys containing tin with or without antimony, it is customary to separate the tin, and the antimony if present, by nitric acid attack whereby these metals are precipitated as metastannic and metantimonic acids, respectively. If lead, phosphorus, copper, and iron are present, considerable quantities of these metals are adsorbed and dragged down with the precipitated metastannic and metantimonic acids, wherefore the usual procedures call for the purification of the ignited precipitate by fusion with six times its weight of a mixture of equal parts of sodium carbonate and pure sulphur.[1] This process of purification is not only tedious and cumbersome, but also requires considerable practice and skill if reliable results are to be expected. Therefore, it is often preferred to avoid attack by nitric acid. However, there are advantages to be gained in the early separation of tin and antimony in the analysis of nonferrous alloys, so that if the extent of adsorption were known, it would seem that valuable data could be furnished the analyst.

In this laboratory, experience in the analysis of nonferrous alloys has pointed out a number of interesting results on the adsorption of lead, chiefly in white metals and copper in bronze by precipitated metastannic and metantimonic acids.

In one set of experiments, white metals containing tin and antimony in a lead base were used. One alloy was of the following composition:

Constituent.	Per cent.
Lead (Pb)	82.81
Tin (Sn)	4.49
Antimony (Sb)	12.03
Iron (Fe)	0.10
Copper (Cu)	0.05
Arsenic (As)	trace

[1] Treadwell and Hall, Analytical Chemistry, 6th ed. John Wiley and Sons, New York 2 (1924) 215.

For technical purposes, iron, copper, and arsenic may be regarded as impurities and the alloy considered to have a Sn: Sb: Pb ratio of 5: 12: 83.

One-half gram of the finely divided alloy was treated with 5 cubic centimeters of concentrated nitric acid (specific gravity, 1.4) followed by 10 cubic centimeters of water. The mixture was placed on a hot plate and when violent action ceased, it was boiled until no more red fumes were given off and the alloy was completely decomposed. The mixture was then transferred to a steam bath where it was evaporated to dryness and the residue baked for about thirty minutes, after which it was taken up with 5 cubic centimeters of concentrated nitric acid and diluted with 50 cubic centimeters of water. The mixture was left on the steam bath and the precipitated substances allowed to settle completely. The precipitate was then filtered and washed alternately with a 2 per cent solution of nitric acid and hot water. Lead was determined in the filtrate by the usual method of conversion into sulphate, followed by extraction with hot acid ammonium acetate and precipitation of lead chromate from the boiling hot acetate extract. The amount of lead thus obtained by duplicate determinations was found to be 80.15 per cent, which is lower than the true value by 2.66 per cent.

As it was thought that possibly the process of boiling the mixture of nitric acid and alloy and subsequent baking of the precipitated oxides might have caused excessive occlusion, the experiment was repeated with the following modifications. The alloy after treatment with nitric acid was heated just so as to expel all red fumes and promote complete digestion, but under no circumstances was the mixture allowed to boil. When the sample was completely decomposed, it was diluted with 50 cubic centimeters of water without any previous evaporation to dryness or baking on the steam bath. The precipitate in the diluted mixture was allowed to settle and then filtered out. When lead was determined in the filtrate in the usual manner, the percentage obtained was 81.48, which is 1.33 per cent lower than the true value. This result was verified by Pedro G. Rivera, of the Bureau of Science. It can be seen that the quantity of lead adsorbed was reduced by the elimination of boiling and baking. When the ignited oxides of tin and antimony were fused with sodium carbonate and sulphur, the quantity of lead occluded was found by electrolysis to be 1.26 per cent, which agrees with the shortage of 1.33 per cent of lead in the filtrate.

The experiments were repeated with another lead-base white metal of the following composition:

Constituent.	Per cent.
Lead (Pb)	85.33
Tin (Sn)	4.12
Antimony (Sb)	10.41
Copper and iron	Trace.

This alloy has a Sn: Sb: Pb ratio of 4 : 11 : 85.

When treated with nitric acid, boiled, and the precipitated oxides of tin and antimony baked, the lead found in the nitric acid filtrate was 82.69 per cent as against 85.33 per cent, which is the true value. The shortage of 2.64 per cent in lead, which is the quantity occluded by the combined oxides, confirms the results of the preceding experiments. When no boiling was resorted to in the decomposition of the alloy and in the expulsion of red nitric fumes, and when the precipitated oxides were not baked, the amount of lead found in the nitric acid filtrate was 84.56 per cent. This value is lower than the true lead content by 0.77 per cent. The quantity of lead occluded is thus seen to be nearly 1 per cent.

From these results, it will be noted that in lead-base alloys containing tin and antimony, the quantity of lead adsorbed varies from 1 to 3 per cent depending on the method of attack and the treatment of the precipitated oxides. Whereas, the practice of baking the precipitated metastannic and metantimonic acids renders the process of filtration easier, still in view of the above results, it does not seem to be practical when due account is taken of the resulting increase in occlusion. It is of interest to note that for a given method of procedure, the quantity of lead occluded is fairly constant. This remark is of special interest, as it might be expected that the quantity of lead occluded would vary from determination to determination.

In view of the results of the foregoing experiments, it is difficult to understand how T. B. Diana [2] has come to the conclusion that in the routine analysis of tin in lead-base alloys containing antimony "the correction for PbO may be neglected." As a matter of fact, Griffin,[3] who gives exactly the same procedure as the one proposed by Diana, prescribes the purification of the ignited oxides of tin and antimony.

[2] The Chemist Analyst **18** (1929) 8.

[3] Technical Methods of Analysis, 2d ed. McGraw Hill Book Co., Inc., New York (1927) 196.

In the case of Babbitt alloys which are high in tin, the quantities of lead and copper occluded by precipitated metastannic and metantimonic acids have been found to vary from 0.1 to 0.5 per cent, seldom if ever higher than 1 per cent. In the case of brass or bronze, this laboratory has confirmed the statement of Griffin,[4] who says that for alloys, "containing less than 10 per cent Sn and less than 0.7 per cent P, no further purification of the mixed oxides is necessary; but if above these limits, the mixed oxides must be purified," by fusion with sodium carbonate and pure sulphur.

Should it be desired to determine tin directly in nonferrous alloys, apparently the best method for technical purposes is that based on iodimetric titration.[5] For the direct determination of antimony, this laboratory uses the method based on the oxidation of trivalent to quinquevalent antimony in sulphuric-hydrochloric acid solution by means of standard potassium permanganate. For a direct determination of lead in alloys containing tin and antimony in a lead base, this laboratory has worked out a method which gives satisfactory results. The process consists of a simultaneous decomposition of the alloy and precipitation of all the lead as sulphate by means of concentrated sulphuric acid. Tin and antimony are held in solution by proper acid concentration. Details of the method are as follows.

One-half gram of fine hack-saw filings is treated with 10 cubic centimeters of concentrated sulphuric acid and heated until the alloy is completely decomposed and all the separated sulphur driven off. The liquid is cooled and then very carefully diluted with 50 cubic centimeters of water. The precipitate of lead sulphate is allowed to settle completely and then filtered and washed several times by decantation with a 5 per cent solution of sulphuric acid followed by cool water. As the lead sulphate precipitate may be contaminated with small amounts of basic salts of tin and antimony, as well as with traces of precipitated sulphur, it is not determined as such. It is extracted with hot acid ammonium acetate and determined as lead chromate in the usual manner.

This method has been found to be efficient in the direct determination of lead in white metals made on a lead base. It affords

[4] Technical Methods of Analysis, 2d ed. (1927) 181.

[5] Hillebrand and Lundell, Applied Inorganic Analysis. John Wiley and Sons, New York (1929) 237. U. S. Bureau of Standards Certificate of Analyses of Standard Samples Nos. 53 and 54.

a fairly clean separation of lead from tin and antimony without loss due to occlusion or solution. It gives concordant results with those of the method based on the solution of the alloy with nitric acid and subsequent recovery of lead occluded in the combined oxides. It also agrees with the method based on the solution of the alloy with tartaric and nitric acids followed by precipitation of lead, as sulphate. Moreover, it possesses the advantage of being rapid and sufficiently accurate for routine analyses. While it might seem as though the decomposition of the alloy with concentrated sulphuric acid would be difficult, this is not the case. When the mixture is heated on a hot plate or on a Bunsen flame, a completely decomposed product is obtained in from twenty to thirty minutes. The presence of sulphuric acid prevents the precipitation of basic tin and antimony salts, and even if small quantities of such basic salts were to separate with the precipitated lead sulphate no harmful effects would result, since the subsequent extraction with ammonium acetate eliminates such impurities. For alloys high in tin, this method is not recommended as it is then not possible to avoid the precipitation of basic salts of tin and antimony in quantities large enough to cause complications.

SUMMARY

A study is presented in this paper on the adsorption and occlusion of lead by metastannic and metantimonic acids, formed by nitric acid attack on nonferrous alloys. In white metals containing tin and antimony in a lead base, the quantity of lead occluded varies from 1 to 3 per cent, a value that is too high to be disregarded as negligible. In alloys high in tin, however, the quantity of lead and copper that may be occluded varies from 0.1 to 0.5 per cent. For a given alloy and a given method of attack, the quantity of lead occluded is constant.

A satisfactory method has been worked out for the direct determination of lead in white metals containing tin and antimony in a lead base.

NAPHTHOL ESTERS OF CHAULMOOGRIC ACID AND CHAULMOOGRYL NAPHTHYLAMINES

By IRENE DE SANTOS and AUGUSTUS P. WEST

Of the Bureau of Science, Manila

Various derivatives of chaulmoogric acid have been made from chaulmoogra oil. In the present investigation the naphthol esters of chaulmoogric acid were prepared as well as the chaulmoogryl naphthylamines. The naphthol esters were made by treating the acid chloride of chaulmoogric acid with the naphthols, while the chaulmoogryl naphthylamines were obtained by treating the acid amide of chaulmoogric acid with the naphthylamines. These new compounds thus prepared will be tested for their therapeutic value. In order to check the formulas of the chaulmoogryl naphthylamines, the nitrogen content was determined. A modification of Meulen's catalytic method [1] was employed for making the nitrogen analyses.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was kindly presented to us by Dr. H. I. Cole, of the Philippine Bureau of Health, and was shipped directly to us from the Culion Leper Colony. The oil was prepared from the seeds of *Hydnocarpus alcalæ* C. de Candolle. This oil contains about 90 per cent of chaulmoogric acid.[2] Since the chaulmoogric acid content of this oil is unusually high it naturally serves as a good source of material for the preparation of chaulmoogric acid and its derivatives and also chaulmoogryl substituted compounds.[3]

The chaulmoogric acid, acid chloride, and acid amide of chaulmoogric acid were prepared according to the procedure of San-

[1] Smith, F. L., and A. P. West, Philip. Journ. Sci. **31** (1926) 265.

[2] Brill, H. C., Philip. Journ. Sci. § A **12** (1917) 37.

[3] Herrera-Batteke, P. P., and A. P. West, Philip. Journ. Sci. **31** (1926) 161. Santiago, S., and A. P. West, Philip. Journ. Sci. **33** (1927) 265; **35** (1928) 405. Santillan, P., and A. P. West, Philip. Journ. Sci. **40** (1929) 493. De Santos, I., and A. P. West, Philip. Journ. Sci. **38** (1929) 293 and 445; **40** (1929) 485; **41** (1930) 373.

tiago and West.[4] Chaulmoogra oil was saponified with alcoholic potassium hydroxide. The residual soaps were decomposed with dilute sulphuric acid and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate and filtered, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resin acids were separated by filtering. The solution was evaporated somewhat and allowed to crystallize. The crude product was recrystallized several times from alcohol (95 per cent). The melting point of the purified chaulmoogric acid was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid with phosphorus trichloride. The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid was allowed to drop slowly into cold concentrated ammonia. The precipitated amide was washed with water and dried. The amide was crystallized from methyl alcohol and also from xylene. The crude product was then dissolved in absolute alcohol, the solution decolorized with vegetable carbon (suchar), and crystallized. The melting point of the amide was 104 to 105° C.

α-NAPHTHOL ESTER OF CHAULMOOGRIC ACID

$$\left.\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array}\right\rangle CH(CH_2)_{12}COO\text{-}\alpha\text{-}C_{10}H_7$$

In the preparation of this compound 20 grams of chaulmoogric acid were treated with 2.3 cubic centimeters of phosphorus trichloride. The acid chloride of chaulmoogric acid, thus obtained, was then mixed with 10 grams of α-naphthol. The flask containing the materials was heated in an oil bath (Crisco) at a temperature of about 100° C., until no more acid vapors were evolved. This required about eight days. The reaction product was a dark brown oil. This was poured into water and extracted with ether. The ether extract was then washed with water until free of acid. The extract was then dehydrated with anhydrous sodium sulphate, filtered and distilled to remove the ether. The residue, which was a thick dark-colored oil, was then distilled under reduced pressure. A small amount of liquid distilled over at 180° C., under 14 millimeters pressure. The

[4] Philip. Journ. Sci. 33 (1927) 265.

residue in the flask was dissolved in methyl alcohol and decolorized twice with vegetable charcoal (suchar). Traces of suchar that remained in the solution were removed by treating with talcum powder and filtering. The solution was then evaporated somewhat and allowed to crystallize. When recrystallized from ethyl alcohol, slightly yellowish crystals melting at 53 to 54.5° C., were obtained. The yield was about 10 per cent. The α-naphthol ester of chaulmoogric acid was found to be soluble in the following solvents: Ethyl alcohol, acetone, amyl alcohol, chloroform, ether, carbon bisulphide, petroleum ether, ethyl acetate, ethyl benzoate, and propyl alcohol.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{28}H_{38}O_2$	82.70	9.43
Found	82.58	9.59

β-NAPHTHOL ESTER OF CHAULMOOGRIC ACID

$$\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array} \Big\rangle CH(CH_2)_{12}COO\text{-}\beta\text{-}C_{10}H_7$$

The chaulmoogric acid (20 grams) was converted into the acid chloride, which was then treated with 10 grams of β-naphthol. The mixture was heated in a Crisco oil bath (125° C.) until no more acid vapors were evolved. This required about six days. The reaction product, which was a dark brown solid, was dissolved in methyl alcohol and decolorized three times by treating with suchar. After removing traces of suchar with talcum powder the solution was allowed to evaporate somewhat and crystallize. White crystals, which melted at 49.5 to 51° C., were obtained. The yield was about 50 per cent. The β-naphthol ester of chaulmoogric acid dissolves readily in the following cold solvents: Ethyl alcohol, acetone, amyl alcohol, chloroform, ether, carbon bisulphide, ethyl acetate, ethyl benzoate, xylene, and propyl alcohol.

Analysis:

	Carbon. Per cent.	Hydrogen. Per cent.
Calculated for $C_{28}H_{38}O_2$	82.70	9.43
Found	82.55	9.76

CHAULMOOGRYL-α-NAPHTHYLAMINE

$$\begin{array}{l} CH{=}CH \\ | \\ CH_2{-}CH_2 \end{array} \Big\rangle CH(CH_2)_{12}CONH\text{-}\alpha\text{-}C_{10}H_7$$

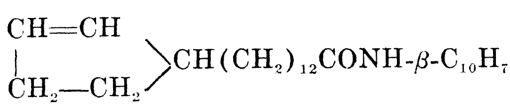
Chaulmoogric acid (20 grams) was converted into the acid chloride of chaulmoogric acid, which was then treated with

ammonia. The acid amide of chaulmoogric acid, thus prepared, was mixed with 8 grams of α-naphthylamine (Kelbe's reaction).[5] The mixture was heated in a Crisco oil bath (100° C.) until no more ammonia vapors were evolved. This required about five days. The reaction product, which was a brown solid, was dissolved in methyl alcohol. The solution was treated three times with suchar and once with talcum. When allowed to crystallize, slightly yellowish crystals were obtained. These crystals, which had a somewhat unpleasant odor, melted at 93 to 95° C. The yield was about 30 per cent. Chaulmoogryl α-naphthylamine is readily soluble in acetone, ethyl alcohol, amyl alcohol, ether, chloroform, carbon bisulphide, ethyl benzoate, ethyl acetate, xylene, and propyl alcohol.

Analysis:

	Nitrogen. Per cent.
Calculated for $C_{28}H_{39}NO$	3.46
Found	3.45

CHAULMOOGRYL-β-NAPHTHYLAMINE



The acid amide of chaulmoogric acid, prepared from 20 grams of chaulmoogric acid, was treated with 8 grams of β-naphthylamine. The mixture was heated in a Crisco oil bath (115° C.) for a week. The reaction product was a dark-colored solid. This was dissolved in methyl alcohol and the solution treated twice with suchar and once with talcum. When evaporated somewhat, slightly yellowish crystals were obtained. The melting point was 96 to 98° C., and the yield about 40 per cent. Chaulmoogryl-β-naphthylamine dissolves readily in the following: absolute alcohol, acetone, amyl alcohol, carbon bisulphide, chloroform, ether, ethyl acetate, ethyl benzoate, propyl alcohol, and xylene.

Analysis:

	Nitrogen. Per cent.
Calculated for $C_{28}H_{39}NO$	3.46
Found	3.34

SUMMARY

Four compounds were prepared in this investigation; namely, two naphthol esters of chaulmoogric acid and two chaulmoogryl naphthylamines.

[5] Ber. Deut. Chem. Gesell. **16** (1883) 1199.

The naphthol esters of chaulmoogric acid were made by treating the acid chloride of chaulmoogric acid with the naphthols, while the chaulmoogryl naphthylamines were obtained by treating the acid amide of chaulmoogric acid with the naphthylamines. Our results indicate that these compounds may be prepared rather easily.

ACKNOWLEDGMENT

We wish to express our thanks and appreciation to Dr. Otto Schöbl and Miss Rita Villaamil, of the Bureau of Science, Manila, for determining the bactericidal properties of these compounds.

NOTES ON PHILIPPINE NABIDÆ, WITH A CATALOGUE OF THE SPECIES OF GORPIS (HEMIPTERA)[1]

By Halbert M. Harris

Of Ames, Iowa

ONE TEXT FIGURE

Through the courtesy of Dr. A. Wetmore and Dr. Harold Morrison, of the United States National Museum, a part of the Nabidæ taken by Prof. C. F. Baker in the Philippine Islands has come to me for study. This collection, while consisting of only a few species, contains some little-known forms, including four new species, and adds considerably to our understanding of Oriental nabids.

ARISTONABIS REUTERI Bergroth.

Aristonabis reuteri Bergroth, Philip. Journ. Sci. § D 13 (1918) 117.

Specimens are at hand from Iligan (type locality) and Butuan, Mindanao; Malinao, Tayabas; Cuernos Mountains, Negros; and Samar. All are females; the male is unknown. The Iligan specimen (type?) agrees well in color with Bergroth's description except that the pronotal collar is luteous, concolorous with the anterior lobe. The other examples show the variation in color that may be expected in this species, the head, pronotum, apex of corium, abdomen, and legs being concolorously luteous in one while in another they are, respectively, concolorously sanguineous. The ratio of pronotal length to width is 33 : 52. Other proportions as given by Bergroth do not hold for the specimens before me. The pronotal width at collar (19) is slightly more than half that of anterior lobe (30), which in turn is distinctly not "twice broader than head" (18). While the size is somewhat variable, the proportions are constant. Length, 4.8 to 5.8 millimeters; width, 1.8 to 2.3.

PHORTICUS VARIEGATUS sp. nov.

Oblong, rather thickly clothed with semierect, fine, pale hairs; brownish, variegated with ochraceous. Head shiny, testaceous,

[1] Contribution from the Department of Zoölogy and Entomology, Iowa State College, Ames, Iowa.

paler distally, the apex almost flavous; as broad as long (male, 15 : 15; female, 17 : 17), somewhat tumid beneath. Eyes reddish, rather coarsely granular. Ocelli prominent. Antennæ flavo-testaceous, segment II slightly darker on basal two-thirds; segments I and II stout, I with its apex distinctly surpassing tip of head, II gradually enlarged distally, all rather thickly clothed with fine hairs; proportional lengths of segments, I : II : III : IV = 7 : 12 : 12 : 14. Rostrum pale testaceous, the apical segments paler; segment III somewhat swollen, proportion of segments, II : III : IV = 12 : 9 : 6.

Pronotum brown, the anterior lobe paler, with a triangular patch on the apical one-fourth ochraceous; broader than long (male, 35 : 28; female, 43 : 31), transversely impressed behind the middle, the impression bearing a row of coarse punctures; anterior lobe with a distinct median longitudinal sulcus on the disc, the sulcus deepest where it ends just before transverse depression. Scutellum concolorous with basal lobe of pronotum, the apex slightly paler; deeply foveate on the disc, the base strongly transversely depressed, the sides sinuate and provided with a row of coarse punctures along each side before the apex. Hemelytra brown, a rectangular spot at the base (extending to a point opposite middle of scutellum), a smaller, less-distinct oval spot in outer apical angle of corium, and an irregular patch on disc of corium and apex of clavus ochraceous. Membrane smoky brown, a small area joining outer apical angle of corium pale to whitish; extending to (female) or scarcely to (male) tip of abdomen. Connexivum exposed, its segments indistinct. Undersurface testaceous to brownish; legs flavotestaceous, the anterior femora except base and apex darker. Anterior femora incrassate, armed before the middle with a stout tooth and finely denticulate from there towards apex; anterior tibiæ strongly widened distally, their apices with distinct fossæ. Intermediate and posterior legs simple, pilose, unarmed. Venter thickly pilose, the segments with a row of coarse punctures along their bases. Length, male and female, 1.9 to 2.5 millimeters; width, 0.74 to 1 millimeter.

Holotype (male) and allotype (female), Mount Maquiling, Luzon, C. F. Baker, collector. Paratypes, 17 males and 5 females taken with type; 2 males and 2 females, Kolambugan, Mindanao; 1 female, Tangkulan, Bukidnon; 1 male, Mount Banahao, Luzon. Holotype and allotype in collection of the United States National Museum. Paratypes in the collections of United States National Museum and of the author.

In this beautiful little species the intensity of the brownish color varies, but the pattern is constant. The pale discal patch of the elytra occupies only the two inner cells of the corium and the apex of the clavus and is interrupted by the darker veins. The segments of the antennæ and rostrum of the female are slightly longer than in the male.

ALLOEORHYNCHUS VINULUS Stål.

Alloeorhynchus vinulus STÅL, Ann. Soc. Ent. France, IV 4 (1864) 59.

Alloeorhynchus pulchellus STÅL, Öfv. Svenska Vet. Soc. Förh. 27 (1870) 675.

Alloeorrhynchus vinulus REUTER et POPPIUS, Acta Soc. Sci. Fenn. 37 No. 2 (1909) 34, 37.

A nice series of this species is at hand from Los Baños and Mount Maquiling, Luzon. The writer has also seen a specimen, belonging to the Hamburg Museum, from Phuc-Son, Annam.

ALLOEORRHYNCHUS BAKERI sp. nov. Fig. 1, a.

Elongate oval, rather flat and depressed. Fuscous brown to piceous, the apical segment of rostrum, margin of abdomen along basal half, distal half of intermediate and posterior tibiæ and all trochanters and tarsi paler; hemelytra with a large oval patch on corium, extending inward to inner vein, reddish yellow. Shiny, the scutellum, hemelytra, excepting narrow costal margin, and metapleura dull. Head broader than long (51 : 45); vertex arched, its width equal to length of anteocular part of head (23 : 23); gula flat. Eyes large, as seen from the side projecting below the gula, their length from above equal to width of vertex. Ocelli prominent. Antennæ pilose, segment I extending slightly beyond apex of head; proportion of segments, I : II : III : IV = 18 : 68 : 49 : (52?). Rostrum with segment I rather horizontal, continued in same line with apex of head, II and III stout, II not reaching to base of eyes, III slender; proportion of segments, II : III : IV = 40 : 35 : 27.

Pronotum smooth, rather flat, beset with numerous long stout hairs, broader than long (105 : 78), constricted well behind the middle, the anterior lobe with a short, shallow, median, longitudinal depression before the base; posterior lobe strongly widened, its basal margin almost straight. Scutellum clothed with numerous long upright hairs, bifoveate and slightly rugose on the disc, the sides raised and somewhat sinuate, the extreme apex truncate and shiny. Hemelytra smooth, with many upright brown hairs, the sides strongly sinuate; the clavus with a double row of coarse punctures along the vein and a few punctures

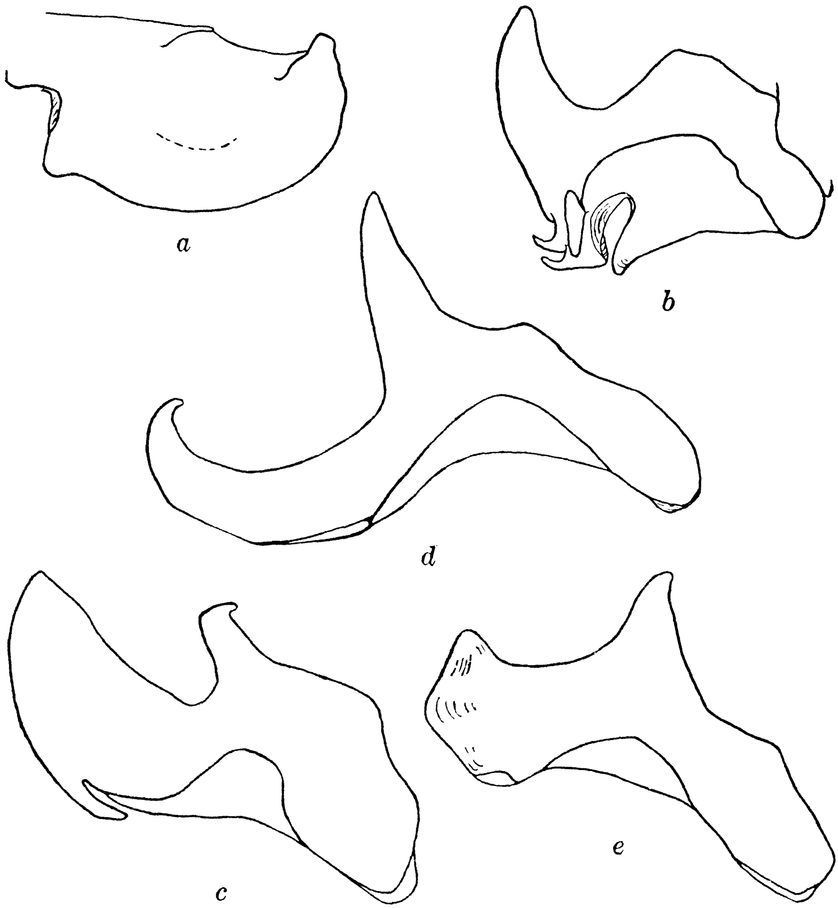


FIG. 1. Male claspers of various nabids; *a, Alloeorrhynchus bakeri* sp. nov.; *b, Nabis tagalicus* Stål; *c, Gorpis sordidus* Reuter; *d, G. flavicans* sp. nov.; *e, G. philippinensis* Stål.

along its inner margin next to apical half of scutellum; corium with a single row of punctures along the inner vein, its other veins obsolete; membrane smoky, slightly surpassing tip of abdomen. Mesosternum at the rear and metasternum throughout with a sharp median longitudinal carina. Metapleuron rugose, the canal shiny, its apex raised, free from pleuron and curved posteriorly. Legs thickly pilose and also setose, anterior and intermediate femora armed beneath throughout their lengths with many black spinelike teeth; anterior tibiæ strongly widened distally, serrately dentate within, the apex with a prominent spongy fossa; intermediate tibiæ faintly curved, armed within, and with a small apical pad. Venter with numerous long hairs;

the genital segment depressed on each side, the median ventral part produced into a prominent process. Clasper with broad blade (fig. 1, *e*). Length, 7.4 millimeters; width of pronotum, 2.1; width of abdomen, 2.8.

Holotype, male, Samar, Philippines, C. F. Baker, collector; in collection of the United States National Museum.

This species appertains to the subgenus *Psilistus* Stål and may be readily separated from the other members of that group by its size and coloration. The yellow patches of the hemelytra are more or less suffused and flecked with blood red. The type bears the number 23469 and the label, *Alloeorhynchus bakeri* Bergr., in Professor Baker's handwriting.

NABIS TAGALICUS Stål. Fig. 1, b.

Nabis tagalicus STÅL, Freg. Eug. Resa, Ins. (1859) 261.

Nabis tagalicus REUTER, Öfv. Vet. Akad. Förh. 29 No. 6 (1872) 88, fig. 8.

Nabis tagalicus REUTER, Mém. Soc. Ent. Belg. 15 (1908) 105, 107.

This species belongs to the subgenus *Stenonabis* Reuter. Numerous specimens from Los Baños and Mount Maquiling, Luzon, are present in the Baker collection. The claspers of the males are produced on the lower outer margin of their blades into three hooklike processes (fig. 1, *d*).

GORPIS SORDIDUS Reuter. Fig. 1, c.

Gorpis sordida REUTER, Ann. Soc. Ent. Belg. 52 (1909) 428.

Gorpis sordidus POPPIUS, Ann. Mus. Zool. Acad. Sci. 19 (1914) 139.

Numerous specimens of this species are at hand from the following localities: Los Baños and Mount Maquiling, Laguna Province; Imugan, Nueva Vizcaya Province; and Baguio, Mountain Province, Luzon. Northwestern Panay. Samar Island. Surigao, Zamboanga, and Butuan, Mindanao. The species originally was described from New Guinea and Deslacs Island and afterwards was recorded from Los Baños, Philippine Islands. The color markings, as shown by the series at hand, are somewhat variable, although the pattern is fairly constant. Some specimens have sordid- and nigro-fuscous markings exactly as Reuter has described them. In other specimens, however, these colors are replaced by a testaceous, while the lighter markings of the typical form are obsolete and scarcely discernible.

Head longer than broad (25 : 21), eyes slightly shorter than width of vertex (9 : 10); antennal formula, 54 : 74 : 95 : 44; rostral formula, 36 : 27 : 13. Pronotum slightly shorter than

broad (male, 37 : 38; female, 42 : 45). Length, 8.5 to 10.5 millimeters; width, 1.6 to 1.8.

GORPIS FLAVICANS sp. nov. Fig. 1, d.

Pale flavous, shiny, thinly clothed with fine whitish pubescence; gula, sides of thorax, legs, and venter also with longer fine hairs; posterior lobe of pronotum coarsely punctate, hemelytra stippled with extremely fine, whitish punctures; head more or less entirely, eyes, ocelli, pronotum along the sides, first antennal segment beneath along basal half, a band on sides of anterior femora before the middle and another on apical third, and subapical ring on posterior femora faintly darker or rufescent; hemelytra somewhat whitish, the corium in greater part and the membrane translucent. Head longer than broad (27 : 23), vertex transversely depressed in front of ocelli; eyes prominent, the length of one slightly greater than width of vertex; ocelli about as far from each other as from the eyes. Antennæ slender, finely pubescent; formula, 53 : 74 : 90 : 42. Rostral formula, 30 : 27 : 13. Pronotum subequally as long as broad (male, 41 : 42; female, 47 : 48), the anterior lobe more gradually raised in front but more distinctly arched on the disc than in *sordidus*. Scutellum with raised apex broader and more truncate than in *sordidus*. Hemelytra extending beyond apex of abdomen; cells of corium (irregularly) and membrane translucent. Venter with a few longer hairs at apex. Male clasper with the blade produced at apex into a long sicklelike process (fig. 1, *b*).

Holotype, male, and allotype, female, Kolambugan, Mindanao, in collection of the United States National Museum. Paratypes, male and female, Basilan Island, in author's collection.

GORPIS PHILIPPINENSIS sp. nov. Fig 1, e.

Closely related to *G. flavicans* sp. nov.; size, proportions, and color similar, the females almost indistinguishable from those of that species, but the males easily recognized by the differently constructed genital claspers. The rufescent markings of anterior and posterior femora never (?) so distinct as they are in *flavicans;* the prothorax as measured from above slightly narrower across acetabulæ and across the postmedian pronotal constriction; anterior lobe of pronotum not so highly arched, its apex more gradually raised behind collar; and eyes slightly smaller and less prominent.

Clasper constructed on same plan but with outer portion of blade rectangular, the sides at apex produced into recurved

processes (fig. 1, *c*). Length, 9.5 to 11 millimeters; width, 1.7 to 2.1.

Holotype, male, Mount Maquiling, Luzon, and allotype, female, Penang Island, in collection of the United States National Museum. Paratypes, 3 males, Mount Banahao, Luzon, 1 male, Sibuyan Island, and 1 female, Penang Island, in collections of the United States National Museum and of the writer.

In 1909 Reuter[2] issued a monographic study of the genus *Gorpis* Stål, giving a diagnostic key to the seven known species. Unfortunately, the key was based, perhaps through necessity because of the absence of males, almost entirely on color characters. As is brought out by a study of the specimens before me, color, at least in some species of the genus, is so variable that feebly and strongly marked individuals of the same species will run to entirely different sections of Reuter's key. Furthermore, the females of many of the species, if one may judge the genus from the three forms before me, bid fair to be extremely difficult to separate structurally. It will not prove unlikely then, as our knowledge of the group becomes more nearly complete, that several of the names now in use shall fall into synonymy, since the greater portion of the species have been described from female examples. It is to be hoped that the males of more species will be discovered and the claspers, which are excellent specific characters, figured. The following is a catalogue of the species of the genus, with the known distribution, and with the sex and place of deposition of type specimens:

Genus GORPIS Stål

Haplotype, *cribraticollis* Stål.

1. GORPIS ACUTISPINIS Reuter.

Mém. Soc. Ent. Belg. 15 (1908) 96.
Ann. Soc. Ent. Belg. 53 (1909) 425.
Madagascar. Type female, in Mus. Paris.

2. GORPIS ALBICANS Reuter.

Ann. Soc. Ent. Belg. 53 (1909) 426.
Insula Nias. Type female, in Mus. Genov.

3. GORPIS ANNULATUS Paiva.

Rec. Indian Museum 16 (1919) 370, pl. 36, fig. 4.
Assam. Type in Mus. Zool. Survey of India.

[2] Ann. Soc. Ent. Belg. 53: 423–430.

4. GORPIS APICALIS Reuter.

Ann. Soc. Ent. Belg. **53** (1909) 429.

Kilimanjaro, Africa. Type female, in Mus. Paris.

POPPIUS in Sjostedt's Kili.-Meru Exped. 12 (4) (1910) 59.

5. GORPIS CINCTICRUS Reuter.

Ann. Soc. Ent. Belg. **53** (1909) 428.

Madagascar. Type female, in Mus. Paris.

6. GORPIS CRIBRATICOLLIS Stål.

Öfv. Svenska Vet.-Akad. Förh. **16** (1859) 377.

Ceylon; Java. Type, female, in Mus. Berol.

DISTANT, Fauna Brit. Ind., Rhyn. 2 (1904) 398, fig. 254.

REUTER Ann. Soc. Ent. Belg. **53** (1909) 427.

POPPIUS, Tijd. v. Ent. **56** (1914) 181.

7. GORPIS ELEGANS Poppius.

Tijd. v. Ent. **56** (1914) 181.

Sumatra. Type in Mus. Helsingfors.

8. GORPIS FLAVICANS Harris, sp. nov.

Philippines. Types, male and female, in U. S. Nat. Mus.

9. GORPIS HUMERALIS (Distant).

Dodonaeus humeralis DISTANT, Fauna Brit. Ind., Rhyn. 2 (1904) 399, fig. 255.

Gorpis (*Dodonaeus*) *humeralis* REUTER, Mém. Soc. Ent. Belg. **15** (1908) 95.

Sikhim, India. Type, female, in British Mus.

10. GORPIS PHILIPPINENSIS Harris, sp. nov.

Philippines. Types, male and female, in U. S. Nat. Mus.

11. GORPIS RUFINERVIS Poppius.

Ann. Mus. Zool. Acad. Sci. **19** (1914) 138.

Victoria Nyanza, Africa. Type, female, in Mus. Petrop.

12. GORPIS SORDIDUS Reuter.

Ann. Soc. Ent. Belg. **53** (1909) 428.

New Guinea; Insula Deslacs. Types, male and female, in Mus. Hung.; Mus. Genov.

13. GORPIS SUBTILIS Reuter.

Ann. Soc. Ent. Belg. **53** (1909) 427.

Insula Fidschi. Type in Mus. Holm.

14. GORPIS TRANSVAALENSIS Schouteden.

Rev. Zool. Afr. **6** (1919) 241.

Transvaal. Type, female, in Schouteden collection.

ILLUSTRATION

TEXT FIG. 1. Male claspers of various nabids; *a, Alloeorrhynchus bakeri* sp. nov.; *b, Nabis tagalicus* Stål; *c, Gorpis sordidus* Reuter; *d, G. flavicans* sp. nov.; *e, G. philippinensis* Stål.

AN INQUIRY INTO THE SO-CALLED LATENT INFECTION IN YAWS-VACCINATED MONKEYS AS A POSSIBLE RESULT OF THE TEST FOR IMMUNITY BY INTRADERMAL INOCULATION WITH LIVING YAWS MATERIAL

By ISAO MIYAO[1]

Of the Division of Biology and Serum Laboratory
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The theory that latent infection is the cause of resistance and not the consequence of immunity in treponematoses is still found in the literature. Therefore, one of the objections to the interpretation of the findings made in the test for immunity in yaws-vaccinated monkeys was the possibility that following the first infection, as a test for immunity, a latent infection developed in vaccinated and immune animals. However, the development of the resistance to inoculation in yaws-vaccinated monkeys was too sudden to be due to the infection as a test for immunity, and the resistance was found constantly in all vaccinated monkeys that were inoculated later than six weeks after the vaccination began.[2]

Nevertheless, it was deemed advisable to make an experimental inquiry into the possibility of latent infection in such animals, particularly in view of the great stress that is laid on this condition in experimental syphilis as an explanation of resistance to inoculation.

It was found by Schöbl and Hasselmann [3] that in yaws-infected monkeys the treponema of yaws may be detected in the regional lymph glands corresponding to the lesion while the lesion is still active, but not after the lesion has healed spontaneously. This condition, however, has not been investigated in monkeys immune as a consequence of yaws vaccination. I have, therefore, undertaken the following experiment.

[1] Lieutenant Surgeon, Imperial Japanese Navy.
[2] Philip. Journ. Sci. **42** (June, 1930).
[3] Philip. Journ. Sci. **35** (1928) 297.

From the series of monkeys vaccinated with killed yaws vaccine [4] and which were infected with live yaws material subsequent to the vaccination and found immune, all males were selected. Having been infected by intradermal inoculation with live material on the scrotum, these animals failed to develop yaws lesions and were particularly suitable for this experiment because the regional lymph gland corresponding to the place of inoculation could be easily located.

At intervals of time after the inoculation with living yaws material, as shown in Table 1, the inguinal glands corresponding to the place of inoculation were removed surgically and aseptically.

The glands were triturated in a sterile mortar and a small amount of physiologic salt solution was added.

The emulsion of the entire gland was taken up in a small hypodermic syringe and injected intradermally, following the method indicated by Schöbl.[5]

The small residue of the emulsion of the lymph gland was used for microscopic dark-field examination.

Treponemas in the skin lesions travel, or are carried, through lymphatic spaces and thus naturally reach the first barrier, the corresponding lymph gland, as pointed out by Schöbl.[6]

It becomes, therefore, important to know whether or not the treponemas reach the glands and remain there for a sufficient length of time following inoculation of the vaccine-immune monkey. Therefore, we proceeded to ascertain whether or not treponemas were present and alive in the regional inguinal glands of the yaws-vaccinated monkeys, following the test for immunity by intradermal injection of living yaws material, even though a skin lesion failed to develop.

For this purpose the following two procedures were applied:

1. Microscopic dark-field examination to search for treponemas in the glands.

2. Test of their presence and viability by means of inoculation into healthy animals.

In order to control the entire experimental procedure, inguinal lymph glands were removed from an animal with active

[4] Philip. Journ. Sci. 42 (June, 1930).
[5] Philip. Journ. Sci. 35 (1928).
[6] Philip. Journ. Sci. 35 (1928) 297.

scrotal yaws lesions, ground up, emulsified with physiologic salt solution, and inoculated intradermally into a healthy normal monkey.

The experimental animals consisted of five monkeys.

Four monkeys were vaccinated three times with killed yaws vaccine heated at 60° C. for one hour.

The interval between the time of lymphadenectomy and the test for immunity by intradermal inoculation with living treponemas is indicated in Table 1; namely, the first monkey three weeks three days, the second four weeks, the third six weeks, and the fourth eleven weeks after the last inoculation with live yaws material. The inguinal glands corresponding to the site of inoculation with yaws were removed and injected intradermally into normal healthy monkeys on the eyebrows (h–1, g–1, h–2, and g–2).

The inoculated animals were kept under observation for not less than two months; that is to say, twice the normal incubation period.

The microscopic examination of emulsified lymph glands by means of dark-field illumination resulted in negative findings, not only in yaws-immune animals, but also in the normal control animal with active yaws lesions.

From Table 1, it is evident that not a single yaws-vaccinated monkey harbored viable treponemas of yaws in the corresponding lymph glands.

The control nonimmune monkey that had an extensive active yaws lesion on the scrotum at the time the lymph glands were removed contained viable treponemas.

CONCLUSIONS

Monkeys found immune to yaws when inoculated with live yaws material subsequent to yaws vaccination showed no evidence of so-called "latent infection."

ACKNOWLEDGMENT

I wish to express my sincere thanks to Dr. Otto Schöbl, chief of the division of biology and serum laboratory, Bureau of Science, for guidance and assistance rendered in the course of this work.

TABLE 1.—*Showing the results of test for latent infection performed on yaws-vaccinated monkeys following inoculation with yaws.*

[+, typical yaws lesion; ±, atypical yaws lesion; —, no lesion.]

Vaccine-immune donor monkey.	Last inoculation with yaws.	Result.	Lymphadenectomy.	Interval between last inoculation and lymphadenectomy.	Recipient monkey.	Result.	
						Microscopic.	Take.
W-22-a	[a] VI- 4-28	—	VI-28-28	3 weeks 3 days	h-1	—	—
W-25-a	VI-26-28	—	VII-24-28	4 weeks	g-1	—	—
W-25-b	VI-25-28	—	VIII- 9-28	6 weeks	h-3	—	—
W-22-b	VI- 4-28	—	VIII-20-28	11 weeks	g-2	—	—
D-16. Control active yaws	V-24-28	+	VII- 2-28	5 weeks 5 days	h-2	—	±

[a] These letters and figures indicate month, day, and year: thus, VI-4-28 means June 4, 1928.

IMMUNOLOGIC RELATION BETWEEN THREE PHILIPPINE STRAINS OF YAWS

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It has been proven experimentally by Schöbl that immunity with a homologous strain of yaws develops in Philippine monkeys within six months after inoculation, provided that a local yaw develops only at the place of first inoculation.[2] This finding has been confirmed by Tanabe.[3] It has been further demonstrated by Schöbl and Miyao that Philippine monkeys immune to yaws are also immune to cutaneous inoculation with syphilis.[4]

It was, therefore, to be expected that heterologous strains of *Treponema pertenue* would show likewise immunologic reciprocity. However, in view of the fact that some strains of yaws produce more-vigorous local lesions of longer duration than other strains in the same kind of animals, it was desirable to carry out experiments concerning the immunologic relation between several strains of yaws, particularly since Schöbl[5] has demonstrated that the strength and the rapidity of the onset of immunity in yaws depend on the extent and intensity of yaws infection.[6]

Three strains of yaws isolated in the Philippines and designated by the names of the patients were employed in this experiment. The animals were inoculated with one of the three strains and were superinoculated with another of the three

[1] Lieutenant Surgeon, Imperial Japanese Navy.

[2] Philip. Journ. Sci. 35 (1928).

[3] Philip. Journ. Sci. 40 (1929).

[4] Loc. cit.

[5] Philip. Journ. Sci. 35 (1928).

[6] Loc. cit.

strains at about the time when immunity to yaws sets in, according to the experiments with homologous strain of yaws performed by Schöbl.[7]

Of these three strains the one designated by the name "Kadangan" is a strain of yaws that was isolated from a patient in the Philippines by inoculation to Philippine monkeys, March 4, 1925. This strain has been thoroughly studied by Schöbl and kept alive to the present time by successive passages through Philippine monkeys.[8]

The second strain, designated "Guzon" strain, was also isolated from a patient in the Philippine Islands, November 15, 1928, and was passed through monkeys. It produced typical local yaw and distinct serologic reactions in the inoculated monkeys.

The third strain included in this experiment was the Katayama strain. It was isolated in January, 1928, from a Japanese who contracted yaws in Manila.[9] This strain was characteristic, producing in Philippine monkeys small and short-lived local lesions.

The tabulated results of our experiments show that immunologic reciprocity between heterologous strains of yaws exists. The time necessary for the development of immunity produced by infection with one strain of yaws towards another strain may vary somewhat; particularly if the immunizing strain produces feeble and short-lived lesions, the development of cross immunity may be delayed, as was the case with the Katayama strain.

ACKNOWLEDGMENT

Thanks are due to Dr. Otto Schöbl, chief of the division of biology and serum laboratory, Bureau of Science, for courtesies received in carrying out these experiments.

[7] Loc. cit.
[8] Loc. cit.
[9] Philip. Journ. Sci. 41 (1930) 13.

TABLE 1.—*Showing the results of cross immunity between heterologous Philippine strains of treponema frambœsiæ.*

[+, typical yaws; —, no yaws (immune); 0, not done.]

Designation of monkey.	Inoculated with Kadangan strain of yaws.		Superinoculated with Guzon strain of yaws.	
	Date.	Result.	Date.	Result.
B 6	[a]IV-12-27	+	XII-28-28	—
Y 4	V-31-27	+	XII-28-28	—
K 7	I-15-27	+	XII-28-28	—
T 4	VII- 2-26	+	I- 8-29	—
H 20	XI- 8-26	+	I- 8-29	—
O-c	VII-27-26	+	I- 8-29	—
J-11	III-19-26	+	I-11-29	—
D-8	IV-25-25	+	I-11-29	—
Control	0	0	I- 8-29	+
Do	0	0	XII- 28-28	+
O-d	IV-11-27	+	II-21-29	—
T-15	IX-17-27	+	II-21-29	—
W-6	X-21-27	+	II-21-29	—
W-8	X-25-27	+	II-21-29	—
W-13	II- 7-28	+	II-21-29	—
W-36	II- 1-28	+	II-21-29	—
W-43	II- 6-28	+	II-21-29	—
W-45	II- 7-28	+	II-21-29	—
W-49	II-21-28	+	II-21-29	—
Control	0	0	II-21-29	+
Do	0	0	II-21-29	+
A-8	VIII-17-28	+	II-27-29	—
o-1	VI-21-28	+	II-27-29	—
E-41	II-28-28	+	II-27-29	—
f-2	VI-25-28	+	II-27-29	—
j-1	VIII-17-28	+	II-27-29	—
j-18	VI-26-28	+	II-27-29	—
K-9	VI-26-28	+	II-27-29	—
W-51	II-27-28	+	II-27-29	—
W-55	V- 3-28	+	II-27-29	—
Control	0	0	II-27-29	+
Do	0	0	II-27-29	+

[a] These letters and figures indicate month, day, and year: thus, IV-12-27 means April 12, 1927.

TABLE 2.—*Showing the results of cross immunity between heterologous Philippine strains of treponema framboesiæ.*

[+, typical yaws; —, no yaws (immune); 0, not done.]

Designation of monkey.	Infected with Guzon strain of yaws.		Superinfected with Kadangan strain of yaws.	
	Date.	Result.	Date.	Result.
H-Guzon-24	[a]I- 8-29	+	VIII- 8-29	—
			XI-21-29	—
Guzon m-10	II-21-29	+	XI-19-29	—
Guzon m-12	II-27-29	+	XI-19-29	—
Control	0	0	VIII- 8-29	+
Do	0	0	XI-19-29	+
Do	0	0	XI-21-29	+

[a] These letters and figures indicate month, day, and year; thus, I-8-29 means January 8, 1929.

TABLE 3.—*Showing the results of cross immunity between heterologous Philippine strains of treponema framboesiæ.*

[+, typical yaws; —, no yaws (immune); 0, not done.]

Designation of monkey.	Infected with Katayama strain of yaws.		Superinfected with Kadangan strain of yaws.	
	Date.	Result.	Date.	Result.
Katayama No. 1	[a]I- 3-29	+	VIII- 8-29	+
			XI-21-29	—
Katayama No. 2	III-16-29	+	XI-21-29	—
Control	0	0	XI-21-29	+

[a] These letters and figures indicate month, day, and year; thus, I-3-29 means January 3, 1929.

NOTE: The terms treponema framboesiæ and treponema luis are used for the sake of convenience and not as a suggestion for a new systematic nomenclature.

IS FRAMBŒSIA TROPICA A NOSOLOGIC ENTITY? [1]

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INTRODUCTION

The literature concerning the relation of yaws to syphilis is voluminous. A great many points of differentiation between the two diseases have been brought out. Not a few of these are irrelevant, while others are essential. A good many are of a purely speculative character. Others do not stand the scrutiny of critical experimenters. They fall into five realms of medicine; namely, parasitology, pathology and serology, clinical differential diagnostics and descriptive dermatology, epidemiology, and history of medicine.

The points of differentiation between lues and yaws are enumerated or tabulated in the literature, but only recently an attempt has been made(1) rationally to correlate the findings on which the differential diagnosis of frambœsia and syphilis rests. Thus, the student of tropical medicine was compelled to memorize every point, for fear that he might forget one or another of the differential diagnostic points which, for all the text books tell him, might be the very fundamentals involved in the question. His attention was centered upon the minute and doubtful tinctorial and morphologic differences between *Treponema pallidum* and *Treponema pertenue*, then he was transferred centuries back and confronted by Christopher Columbus, who upon his return to Europe, as some theories would have it, brought with him frambœsia; that is, tropical syphilis.

The long line of arguments, arrayed in favor of the dualistic nature of yaws and syphilis, it would appear, carries insufficient weight to silence the minority who argue that these two diseases are the same. By emphasis on epidemiologic

[1] Presented as thesis for the degree of "Hakushi" in Medicine and prepared under the direction of Dr. Otto Schöbl, chief of the division of biology and serum laboratory, Bureau of Science, Manila.

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observations and on those particular phases of clinical manifestations of one disease, which by themselves cannot be distinguished clinically from analogous lesions of the other disease, the fundamental biologic differences in the nature of the two infections are pushed into the background, and a wide space opens for speculation. Misconception of immunity in general, and of the brand of immunity in particular that is encountered in syphilis, yaws, vaccinia, variola, fixed and street virus of rabies, and perhaps a few more, as well as wrong interpretations of immunologic findings in yaws and syphilis, helped to envelop the problem of identity or duality of these two diseases in a fog, almost mystical, that leads some to seek the solution of the problem in the fifteenth century rather than in present and future experimental and laboratory investigations into the fundamental biologic characteristics of the treponema that causes the disease clinically known as syphilis, and of the treponema that causes the disease clinically known as frambœsia tropica.

In the face of the occasional difficulties in differential clinical diagnosis and the impossibility, for the present, of the differentiation—by morphological, tinctorial, and cultural methods—of treponema luis from treponema frambœsiæ, speculative arguments based on epidemiology and the history of medicine contribute to practical medicine but a sense of confusion and uncertainty. Furthermore, they have no place in concrete science, such as medical research, because they offer at present no tangible proof.

I. AN INTERPRETATION OF THE DIFFERENCES BETWEEN FRAMBŒSIA AND SYPHILIS IN THEIR CLINICAL MANIFESTATIONS AND THEIR DIFFERENT BEHAVIOR WITH REGARD TO HEREDITY, GEOGRAPHIC DISTRIBUTION, INCIDENCE AS TO AGES, TRANSMISSION, IMMUNITY, AND CHEMOTHERAPY.

In the following pages an attempt is presented at an interpretation of the amassed arguments relating to the points of differentiation between the two diseases. As a basis for this interpretation distinct biologic differences between treponema luis and treponema frambœsiæ were considered. It will be seen that without any stretch of the imagination the various observations, offered as points of differentiation between syphilis and yaws, can be rationally correlated with the fundamental biologic peculiarities of the causative agents, as far as known to-day. This correlation is achieved by the application of well-known

and substantiated general principles that have been adopted in basic medical sciences. The entire mass of evidence under discussion can be thus logically reduced to one or two problems. Thus the fundamentals become more evident, and the direction is indicated in which the principles underlying the peculiar biologic differences are to be sought. Those phases of syphilis and yaws that form the clinical border line between the two must be kept out of consideration while the framework of the double structure is being erected, so that we may see whether the double structure will withstand the weight of criticism or whether one of them will collapse.

The early hope of morphologic or tinctorial differentiation of "*Spirochæta pallida*" from "*Spirochæta pallidula seu pertenuis*" has not been realized. The question of the cultural differentiation of the two treponemas still awaits answer. Beyond their successful cultivation no further progress has been made. The once-claimed qualitative distinctions in serology of syphilis and yaws have not been substantiated in later days.

Thus we are restricted for the present largely to a comparison of biologic properties, as revealed by the behavior of treponemas in the body organism and by the tissue response to the infection. However, this need not discourage anyone. The vaccine virus became well known in its biologic properties and the knowledge was fully taken advantage of by practical medicine without the virus itself having ever been seen or cultivated.

The fundamental biologic difference, as far as known at present, between treponema luis and treponema frambœsiæ lies in the pathogenesis of syphilis and yaws.

BRIEFLY DEFINED

The treponema frambœsiæ is epiblastotropic. The treponema luis is panblastotropic with preference to mesoblastic tissues. This definition becomes clear in the course of further discussion.

1. INITIAL LESION

YAWS	SYPHILIS
Treponemas invade epidermis and multiply consequently.	Treponemas invade epidermis and multiply consequently.
The primary efflorescence of the initial lesion is a papule.	The primary efflorescence of the initial lesion is a papule.
Treponemas remain in the superficial layer of the skin;	Treponemas penetrate early into deeper layers of the skin;

consequently, soft œdema or none collects. The œdematous liquid oozes out.

Treponema frambœsiæ localizes in epidermis; consequently, the reaction on the part of the affected tissues is downgrowth of epidermis and upgrowth of granulation tissues. The resulting efflorescence is a papilloma—a yaw. It produces no early change in the blood vessels nor deep œdema; the result is profuse oozing and absence of early ulceration.

Treponemas remain localized in the superficial layers of the skin; consequently, the healing of the early yaws is either by restitution ad integrum or by flat thin superficial scar.

Treponemas show preference to skin; consequently, the initial lesion in a great number of cases persists to and beyond the early metastatic skin eruptions, which in turn last long. The primary lesion lasts so long that it frequently changes into an ulcer of late, so-called tertiary, character.

consequently, deep hard œdema collects at the basis of the lesion. No oozing sclerosis.

Treponema luis penetrates early into the deeper layers of the skin and produces early changes in blood vessels and deep œdema; consequently, the reaction on the part of the affected tissues is necrosis surrounded by deep hard œdema—a chancre.

Treponemas penetrate early into the deeper layers of the skin; consequently, the healing of a chancre is accomplished by a more or less deep branching cicatrization.

Treponemas show mesoblastic preference and penetrate deeply and rapidly into the skin and internal organs; consequently, the chancre heals before the advance of early metastatic eruptions, which in turn are also of short duration.

A chancre heals early and never changes into an ulcerative lesion of late, so-called tertiary, character (gumma).

2. LOCALIZATION OF INITIAL LESION

YAWS

Treponemas are epiblastotropic; consequently, the initial lesion localizes on the skin on the mucocutaneous border of the nose and the mouth, and

SYPHILIS

Treponemas are panblastotropic; consequently, initial and early metastatic lesions localize on the skin, on the lip, on the conjunctiva, on the ex-

on the mucocutaneous border of the external genitals (high altitudes) (2) and the anus.

ternal genitals, at the introitus ad vaginam, on the cervix uteri in the urethra, on the tongue, on the palate, and on the mucous membranes of the rectum.

3. IMMUNITY

YAWS

Treponemas are localized superficially in the early lesions and do not produce early vascular changes, do not penetrate into the deep layers of the skin, invade the lymphatic system and the blood stream only temporarily and do not persist there, and do not localize permanently in other organs; consequently, the immunity is late in developing.

Immunity persists after the treponemas disappear from the tissues.

(Immunity without concomitant, so-called latent, infection.) (3, 4)

Treponemas of yaws immunize against themselves sooner than against treponemas of syphilis. (1)

SYPHILIS

Treponemas penetrate early and establish themselves in the deep layers of the skin, in the lymphatic system, and through the blood stream in the internal organs and produce early vascular changes. Immunity develops much earlier.

The so-called latent infection persists coincident with immunity.

Treponemas of syphilis immunize against themselves far sooner than against treponemas of yaws.

4. METASTATIC LESIONS

YAWS

Due to late development of immunity the metastatic lesion is identical in character with the initial local lesion. Modified metastatic lesions develop later at the time when immunity begins to develop. Therefore, early metastatic lesions are more uniform.

SYPHILIS

Due to early onset of immunity the metastatic lesions are different in character from the initial local lesion; therefore, greater variety of metastatic skin manifestations. Metastatic lesions do not resemble the initial lesion—that is, the chancre.

YAWS	SYPHILIS
Treponemas are epiblastotropic and do not colonize internal organs; therefore, when cutaneous manifestations disappear and the skin is completely sterilized, no relapses occur. (3)	Treponemas are panblastotropic and colonize internal organs; consequently, with healing of skin manifestations the process is not finished, but relapses occur, caused by invasion of tissues by treponemas stored in the internal organs.

5. CHEMOTHERAPY

YAWS	SYPHILIS
Due to exclusive localization of treponemas in the skin and not in other tissues, frambœsia in the early stage is exquisitely amenable to chemotherapeutic treatment.	Treponemas are localized in the skin and other tissues, and skin manifestations of syphilis are promptly amenable to chemotherapeutic treatment, but infection continues from mesoblastic sources.

6. TRANSMISSION

YAWS	SYPHILIS
Treponemas are epiblastotropic, and lesions are confined to skin transmission by direct contact and by insects feeding on the discharge of efflorescences. (5)	Treponemas are panblastotropic, and initial and metastatic lesions are localized around and in body orifices. Transmission is by direct contact and through sexual intercourse (venereal disease).
Treponemas do not localize permanently in lymphatics and blood vessels nor in internal organs; (6) therefore, not in placenta and congenital transmission is absent.	Treponemas are panblastotropic and localize in lymphatics, blood vessels, internal organs, and placenta permanently; therefore, congenital transmission occurs.

7. INCIDENCE AS TO AGES AND LOCALITIES

YAWS	SYPHILIS
Transmission of epiblastotropic treponemas by direct contact of skin and by insects is responsible for heavy incidence among children and in rural districts.	Venereal disease is responsible for heavy incidence after puberty and in large cities.

Treponemas are highly susceptible to low temperature,(5) epiblastotropic; therefore, yaws is influenced in clinical manifestations and geographic distribution by climate; a tropical disease.

Primary and metastatic lesion is specially localized on warm and moist surfaces and body orifices, sexual transmission; therefore, not influenced by climate. Moreover, the treponema of syphilis is far more resistant to adverse conditions prevailing outside of body than the treponema of yaws;(7) therefore, pandemic.

II. DISCUSSION OF THE INTERPRETATION

The differences between yaws and syphilis in their pathogenesis as just pointed out may at first sight look to be more a matter of degree than of kind. However, there are observations of two phenomena which constantly permeate the histopathologic changes and are constantly met with in syphilis and are not found in frambœsia. They are:

1. The localization of treponemas in the epidermis and the lack of vascular changes in early yaws.
2. The localization of treponemas in the corium and mesoblastic tissues and the pronounced vascular changes in syphilis.

These two facts are well known and should not require any further comment. Nevertheless, I am reproducing here the results of histopathologic comparative study of typical yaw (papilloma) and an early skin manifestation of syphilis which resembles a yaw more than any other syphilide, that is condyloma. For the sake of fairness I prefer to use findings of others rather than my own.

The following was abstracted from Hallenberger:(8)

1. HISTOPATHOLOGY OF YAWS AND SYPHILIS

YAWS (PAPILLOMA)

The lesion is covered with epidermis.

Corneal and granular layers are gone; in their place, a lamellar layer of flat nucleated cells is found.

SYPHILIS (CONDYLOMA)

The lesion is covered with epidermis.

Corneal and granular layers are gone; in their place, a lamellar layer of flat nucleated cells is found.

The spaces of these layers are filled with serum, red blood cells, leucocytes, and detritus.	The spaces of these layers are filled with serum, red blood cells, leucocytes, and detritus.
Rete Malphigi shows enormous downgrowth reaching clear to the subcutis.	Rete Malphigi shows slight downgrowth.
The suprapapillary epithelial layer is moderately thickened.	The suprapapillary epithelial layer is slightly thickened.
The interspinal spaces of the epidermis are dilated and filled with polymorphonuclears. They lead frequently to the formation of miliary abscesses located within the epidermis.	The interspinal spaces of the epidermis are dilated and filled with polymorphonuclears. They lead frequently to the formation of miliary abscesses located within the epidermis.
The basal layer of the epidermis shows extensive leucocytic infiltration which extends to papillary bodies. The leucocytes are so numerous that the epithelial cells are subdued and the dividing line between the papillæ and the epidermis is indistinguishable.	
The papillary and subpapillary layer of the corium shows loose cellular infiltration which consists in the centrum of plasma cells almost exclusively, while towards the periphery mononuclears and fibroblasts are also present. Towards the surface (epidermis) polymorphonuclears are predominant. This loose infiltration follows the branching blood vessels like sheets surrounding blood vessels and glands. Giant cells not found. Blood vessels distended show no changes in their walls.	The papillary and subpapillary layer of the corium shows thick, sharply outlined, cellular infiltrations, which follow the blood vessels. They are composed of round cells, plasma cells, fibroblasts, and giant cells. These infiltrations are found in the deep layers of the corium and sometimes even in the subcutis arranged along the blood vessels. The walls of the blood vessels show cellular infiltration and their endothelium is hypertrophic to such a degree as to cause almost complete obliteration.
Levaditi stain shows that treponemas are present only in	Levaditi stain shows that treponemas are predominant

the epidermis within the polymorphonuclear infiltrations.	in the corium and the papillary layer. They are also found within the walls of the blood vessels.

In view of the general knowledge of these two biologic differences between yaws and syphilitic infection, as just recapitulated in the quotation from Hallenberger, these two fundamental biologic differences between yaws and syphilis must be accepted as valid. The deductions, however, I have made in an attempt to explain the differences between yaws and syphilis as given in literature, need further discussion. We shall now discuss the individual points, one by one.

The initial lesion in yaws is a papilloma,(8) in syphilis it is a chancre. Taking the fact that treponema frambœsiæ remains localized in epidermis as established, we can follow the development of a papilloma histologically. Even though at times treponema frambœsiæ is found in a rather deep layer of the lesion, it will be confined to those portions of the lesion that are composed of epidermal columns that have grown deep down into the skin, at times reaching the subcutis. The downgrowth of the epidermal cells in a form of deep columns (acanthosis) must be considered as a reaction on the part of the epidermis to the invasion of the treponema frambœsiæ. The cutis proper responds at a distance to the epidermal invasion by sending leucocytes, predominantly polymorphonuclears, into the epidermis and by upgrowth of the inflammatory granulation tissue of the corium. Blood vessels, however, are not affected. The irritation on the part of the infection is such that the corium responds predominantly by plasmatic cell reaction. The superficial localization in the skin of the yaws lesion naturally is accompanied by soft œdema that is not very much pronounced, because the removal of the lymph from the pathologic tissue by oozing from the large surface is facilitated. There is no change in the blood vessels that would lead to the narrowing or obliteration of the lumen and consequently to necrosis.

In syphilis, on the other hand, the treponema luis penetrates early and is present in the largest numbers in the corium; consequently, the reaction on the part of the corium is more pronounced than on the part of the epidermis. Therefore, the exudate in this early period is predominantly composed of lymphocytes rather than polymorphonuclears. The downgrowth

of the epidermis is not so pronounced and the lesion being located in the corium, the œdema is deep, oozing is not pronounced, and therefore the liquid part of the exudate accumulates within the tissues of the cutis and even subcutis which become indurated. The early changes in the blood vessels lead to the narrowing of the lumen of the blood vessels and even to complete obliteration, which phenomenon combined with the pressure of the interstitial œdema of the cutis is generally taken in pathology as the cause of necrosis; consequently, the primary lesion is a sclerosis and a defect of the superficial part of the skin surrounded, and sets on a deep indurated base.

Yaws heal by restitution or superficial scar formation; syphilis by more or less deep branching scar.

What has been said about the differences in the primary lesion of yaws and syphilis is sufficient explanation for the differences in the results found in the healing of yaws and syphilis. It stands to reason that a superficial predominantly epidermal lesion will more likely heal by restitution or superficial scar than a deep pathologic skin lesion accompanied by necrosis.

The initial lesion in yaws is apt to last much longer than that in syphilis.

The explanation we offer is, of course, deduction from clinical and experimental observations correlated with the fundamental biologic differences of the two treponemas. Relatively little is known about the mechanism of the healing of syphilitic or of yaws lesion. The conception as expressed in the claim (9) that the healing is independent from the development of resistance to superinoculation or reinoculation is founded on sufficient experimental evidence both in humans and in experimental animals. However, little is known about the mechanism of healing. That healing is coincident with destruction of treponemas in the yaws or syphilitic lesion there is no doubt. Following a chemotherapeutic dose the treponemas disappear from the lesion within a few hours; and the early skin lesions, particularly in yaws, melt away, so to speak, before our eyes as a consequence thereof. This proves that with the disappearance of the treponemas from the lesion the lesion heals. This is an established fact observed by many investigators. About the mechanism of the spontaneous healing of treponematous skin lesion we are still in the dark. There are some few points, however, that have been established, and others that indicate the possibility of solving even this problem by experimental investigation.

No indication was found of humoral curative immunity in yaws. Repeatedly, no effect was achieved upon the healing of yaws lesion by injecting directly into the lesions the serum collected from highly resistant animals or man. Another observation, however, seems to point to at least one factor that may be responsible, under natural conditions and without the aid of chemotherapeutic treatment, for the removal and destruction of the treponemas and consequent healing provided they are prevented from multiplying by immunity. It was noticed that whenever intradermal inoculation of yaws material was followed by acute inflammation with pus formation, due to admixture with the pyogenic microbes, the development of a local yaw at the place of inoculation was either greatly delayed or a yaw did not develop at all. This apparently insignificant observation seems to gain weight in connection with the observation of Goodpasture(12) on healing yaws subsequent to theraphy and in connection with studies of Bergel(13) on the influence of leucocytes and their extract upon the changes in morphology and tinctorial behavior of treponema luis. Goodpasture noticed that an extensive disintegration of lymphatic elements and leucocytes takes place within the yaws lesion during the process of healing after injection of neosalvarsan. Bergel made extensive studies on the behavior and changes of *Treponema pallidum* in an animal's body, particularly in the peritoneal cavity, in which he convinced himself of what appeared to be a direct effect and destruction of *Treponema pallidum* by leucocytes, lymphatic elements, and even extracts from lymphatic organs. The complete destruction was preceded by gradual deterioration of *Treponema pallidum*. This process could be delayed or prevented by a colloidal lipoid, such as lecithin. The problem of healing of the treponematous lesion is far from approaching solution, but the importance of lymphatic and leucocytic elements is constantly coming into view.

2. LOCALIZATION OF TREPONEMA FRAMBŒSIÆ AND OF TREPONEMA LUIS

Treponema frambœsiæ is localized superficially and does not produce early vascular lesions; consequently, immunity develops late.

Treponema luis penetrates early into the mesodermic tissues and produces early changes on the vascular system; therefore, immunity develops early.

There is a sufficient amount of recent experimental evidence on immunity to yaws in man and in experimental animals, in which the infection runs a very similar course to that in man, that the immunity to yaws does not develop until after about eight months in man and after six or seven months in the Philippine monkey with local yaw. If we compare these findings with experimental findings on man and monkeys in experimental syphilis we will see that the immunity to syphilis in man starts to develop in fifteen days and is completely developed in thirty days, while in monkeys it develops in forty-five days. This difference in behavior of the two infections with regard to immunity can be logically correlated when the results of subcutaneous immunization of monkeys to yaws is considered.(14) While monkeys that were infected intradermally with yaws were reinoculable for five months and some for even six months, when the yaws material was injected subcutaneously without development of yaws the immunity set in earlier than four months after the initial immunization. In my opinion it seems to indicate strongly that if the treponema frambœsiæ was not barred from penetration into the mesodermic tissues at an early stage of the infection, the immunity would develop much earlier than it does under the natural or experimental conditions where it is placed and maintains itself in the epidermis. That the penetration into the deeper tissues of the treponema frambœsiæ has an influence upon the development of immunity is further evident from the repeated observations on experimental monkeys that developed generalized yaws. If the generalized yaws developed early—the earliest observed took place in an experimental monkey in the third month—the immunity sets in early, that is about the fourth month instead of the seventh. In every case of generalized experimental yaws the immunity develops much earlier than it does as a consequence of local yaw. A similar observation was made on experimentally infected humans. It was noticed that yaws patients became immune to superinfection during the stage of generalized yaws, while patients that exhibited late yaws manifestations were reinoculable for a much longer period of time.(15)

3. THE SKIN LESIONS IN YAWS ARE MORE UNIFORM THAN THOSE IN SYPHILIS

Due to late development of immunity in yaws, metastatic lesions are identical with the initial local lesion; and modified metastatic lesions develop at the time when resistance to super-

infection has partly developed. Therefore, the early skin lesions in yaws are more uniform.

The period of incubation of generalized, so-called secondary, yaws in humans and in monkeys was found by experiments to be the same; that is, ten to twelve weeks. However, the development of immunity to yaws in humans and to local yaw in monkeys was found to be about six months. Consequently, there are three full months during which the yaws manifestations appear, lesions cropping out on the skin without any interference whatsoever on the part of the immunity. The metastatic lesions, therefore, appear to be of the same general character as the primary lesion that is a yaw. It was observed on human volunteers and on experimental monkeys that the protean lesions developed towards the end of the generalized process, being either admixed to typical or almost typical yaws or cropping out without a typical yaw developing at the same time. The previous metastatic typical yaws, of course, may still persist, but in a given case—which may be earlier in one case than in another—the eruptions of the protean lesions are noticed as the last number on the repertory of the generalized yaws skin manifestation. In syphilis on the other hand the early metastatic, so-called secondary, lesion never resembles a fully-developed primary lesion. The closest that a metastatic, or secondary, syphilis in man ever resembles the primary syphilitic lesion is the elevated and rather broad papule covered with a crust, the papule-caustous syphilide.

Finger(16) describes the course of experimental syphilis in monkeys as follows:

> The small wounds caused by the inoculation first heal. But then after an incubation of ten to forty-two on the average twenty-one days there forms at the place of inoculation small spots of reddening, the center of which soon becomes elevated in a form of a nodule. These nodules grow to the size of a lentile and become covered by crust due to superficial disintegration. Under this crust flat sharply outlined reddish yellow erosions are found which exude sanguinolent yellowish serum. By spreading and by confluence of the neighboring erosions more extensive map-like ulceration results which sometimes covers larger areas, for instance almost the entire lid. After existing for variable time but always for several weeks the ulceration heals and leaves either pale or (in case of cynokephalo and corcopithecus) scars inclosed by pigmented margin. The base of the ulceration shows sometimes slight infiltration. The base of the ulcer is somewhat elevated but not particularly indurated while in Anthropoid apes the induration and therefore the resemblance to sclerosis is pronounced. In lower monkeys the course of syphilis terminates mostly with the healing of the primary lesion. In relatively rare cases there appear several weeks after the healing of the initial lesion narrow semicircular infiltrations surrounding the scar. These infiltrations spread towards the periphery in the

form of serpignimous desquamative papules. At times they reach considerable extent and heal leaving pigmentation. In case of the Anthropoid monkeys particularly in chimpanzee there develop, about eight to ten weeks after the inoculation, manifestations of generalized secondary syphilis. Maculous, papulocrustous exanthema on the general integument, the palms of the hands and soles of the feet, ulcerated papules on the mucous membranes.[3]

The immunity in man with regard to treponema luis, as quoted from Neisser,(17) sets in at the end of the first month and is seen to develop at the end of the first two weeks of the duration of the primary lesion.

Treponema frambœsiæ is epiblastotropic and does not gain a foothold on mucous membrane. Treponema luis is panblastotropic and gains a foothold on mucous membrane.

Neither primary nor secondary lesions of yaws occur on mucous membranes. In syphilis, on the contrary, it is a place of predilection. The localization of treponema frambœsiæ in the epidermis and its inability to maintain itself in the mesoblastic tissues is the reason for this different behavior of syphilis and yaws. That absence of primary lesion on the mucous membrane is not accidental, and is a fundamental difference, is brought out by the fact that metastatic yaws lesions likewise do not occur on mucous membrane. The only condition under which a yaws lesion localizes on mucous membrane is by spreading from the mucocutaneous border onto the mucous membrane.(18) This is made possible by the formation of a crust. The oozing and the exudation at the base of the crust make it possible for the treponema frambœsiæ secondarily to maintain itself in a lesion located on the mucous membrane. We see at once the different reaction on the part of the mucous membrane from that of the epidermis. There is no downgrowth of the epithelial cells of the mucous membrane proper such as we see in a skin lesion and the lesion propagates itself by crust containing oozing lymph, disintegrated leucocytes, and superficial epithelial cells of the mucous membrane. In this early lesion it lies adjacent to the membrana propia, is long preserved, and shows no proliferation and penetration in the deep layers of the mucous membrane proper. The reaction on the part of the mucous membrane proper is similar to that encountered in the corium; that is, cellular and œdematous infiltration and plasma-cell accumulation.

[3] Quoted from W. Kolle und H. Hetsch, Die experimentelle Bakteriologie und die Infektionskrakheiten, sechste Auflage, zweiter Band, 873.

Conditions are different in syphilis. The treponemas, having penetrated into the mucous membrane through the slight epithelial erosion, are able to gain a foothold and to propagate in the mucous membrane proper. Therefore, syphilis in its initial and metastatic lesion is manifested on mucous membrane.

It is generally recognized in the literature concerning yaws that neither primary nor metastatic yaws lesions locate on the mucous membrane. The reason for this deviation from the way of localization of syphilis must be sought in the biologic difference; that is, the predilection of treponema frambœsiæ for the epidermis and the predilection of treponema luis for the mesoblastic tissues. The reason for this difference, of course, is difficult to understand, particularly in view of the fact that, as has been frequently observed, both by clinicians and experimenters, an original skin lesion will spread on the mucocutaneous border and from there on to the mucous membrane. Whether or not the gradual transition of epidermis into the mucous membrane with stratified epithelium makes this possible it is difficult to say at present. However, in the absence of the general reason for tissue tropism we cannot give even a suggestion of the underlying principles that are responsible for the epiblastotropism of treponema frambœsiæ and the panblastotropism and mesoblastic tissue preference of treponema luis. However, careful and persistent observation of the development of lesions in experimental investigation on man and susceptible animals brings out the fact that treponema frambœsiæ does not localize on mucous membrane either as a primary lesion or as a metastatic lesion. We may speculate as to the reason for it and say that either the epidermis contains a substance which is necessary for the growth of treponema frambœsiæ, a substance which is absent in other tissues; or, what may be considered more likely, we may say that the epidermis is so differentiated and so void of other tissues that the treponemas are without the reach of the natural defenses of the body. Mucous membranes have usually a very thin epithelium and lie immediately on a layer composed of mesoblastic tissues. We have seen, however, sections prepared from a frambœsia lesion that spread over the mucous membrane covered with high epithelium. It was observed in these sections that the frambœsic process in such a mucous membrane spread on the epithelium alone, while a relatively small reaction at first is provoked in the mucosa proper. Syphilis, on the other hand, is panblasto-

tropic; and the treponemas luis, as soon as they make their way through the integument of skin or mucous membrane, penetrate rapidly into the depth of the skin or the mucous membrane and find themselves at once in a tissue which they prefer. Consequently, both primary and metastatic lesions on mucous membranes occur in syphilis that have no connection whatsoever with the lesions on the skin, either past or present.

4. YAWS IS NOT CONGENITAL; SYPHILIS IS CONGENITAL

From what has been said as to the localization of treponema frambœsiæ and consequently of the localization of the primary and metastatic lesion it need not to be mentioned again that the inability of treponema frambœsiæ permanently to localize and produce lesions in internal organs and, in particular, its inability to attack blood vessels is responsible for the absence of hereditary transmission in yaws. Syphilis, on the other hand, commonly attacks the blood vessels and prefers mesoblastic tissues. Foci of treponema luis are deposited in internal organs, including the blood vessels, and syphilitic anatomical changes in the placenta are common. Therefore, the congenital transmission of syphilis is obvious.

CONCLUSIONS

Biologic differences in organotropism or tissue selectivity between the treponema of yaws and the treponema of syphilis are responsible for the difference between these two diseases with regard to their clinical course, severity of symptoms, heredity, and epidemiology.

The two diseases belong to one group and show close relationship, but are fundamentally distinct.

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NOTE: The terms treponema frambœsiæ and treponema luis are used for the sake of convenience and not as a suggestion for a new systematic nomenclature.

A SURVEY OF PROTOZOA PARASITIC IN PLANTS AND ANIMALS OF THE PHILIPPINE ISLANDS [1]

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FIVE PLATES

INTRODUCTION

So far as known to the writers only a few records have been published of parasitic Protozoa from animals of the Philippine Islands and none from the plants of this region. A knowledge of this subject is of scientific and practical importance. Parasitic protozoans are responsible for many diseases in both domestic and wild animals as well as in man, and certain species occur in plants and may be pathogenic to them. Parasitology has become one of the major subjects in schools of medicine and of hygiene and is of particular interest in the Tropics since parasites are more numerous and seem to be more pathogenic where tropical conditions exist than in temperate regions. An effort has been made by us to examine for protozoans a large number of domestic animals and the commoner wild animals and plants that may be obtained easily for study. The results here published are fragmentary and serve only as the beginning of a large project. They should be of value to students and teachers of parasitology.

Protozoa living in man are not always available but those of lower animals can usually be secured without difficulty; many of these belong to genera that occur in man and several, ap-

[1] From the Department of Parasitology, School of Hygiene and Public Health, University of the Philippines. We wish to express our appreciation of the facilities placed at our disposal by the Director of the School of Hygiene and Public Health and of the assistance of our colleagues, especially that of the Secretary, Dr. Hilario Lara, and of our assistant, Mr. F. S. Manipol.

parently, are of the same species. The life cycles and the methods of transmission of the Protozoa of lower animals are similar to those of the human species, and we can often determine the activities of the latter by observations on species from lower animals. For example, the process of fertilization in the life cycle of the human malarial parasites was first observed by MacCallum (1897) after he had followed the process in the *Haemoproteus* of birds; this discovery played an important rôle in the working out of the mosquito transmission of malaria by Ross (1898), which was also first accomplished with parasites of birds and later was found to be similar to that of human malarial parasites. More recently a new drug, called plasmochin, has been developed as a result of experiments with birds that is effective against human malaria and will probably prove to be a valuable addition to the methods of controlling this disease in man. The Protozoa of lower animals also afford material for experimental purposes. Human beings may sometimes be employed as experimental animals, as in the work of Walker and Sellards (1913) on amœbæ, which was carried out in Manila and is the best experimental work ever done on this subject, but only under exceptional circumstances can such studies be made. Biological surveys of parasitic Protozoa are of interest as they often reveal species previously unknown, add to our knowledge of the distribution of the Protozoa, and furnish evidence of value in studies of the relationships of hosts.

We have studied the parasitic Protozoa of monkeys more thoroughly than those of any other type of lower animal because most of the Protozoa that have been reported from monkeys seem to be morphologically indistinguishable from those living in man. The details of these studies on monkeys will be published in a separate paper. The other animals studied were selected on the basis of availability. They are, for the most part, animals that are easily obtainable in the vicinity of Manila. The brief statements regarding the structure, the life cycles, and the distribution of the types of parasitic Protozoa described, as well as the drawings, have been included as an aid to the discovery and identification of these organisms.

Surveys of the fauna of any region are usually devoted at first to the larger types of animals, such as mammals, birds, reptiles, fishes, etc., or to the more conspicuous species, such as butterflies and dragon flies. Only after these and other groups have been studied do the smaller animals attract attention, and

usually among the last of these to undergo investigation are the parasites, especially protozoan parasites. We are accustomed to think of the naturalists who risked their lives to collect species of Philippine birds and mammals during the nineteenth century as pioneers, and to believe that work of that type is no longer possible, but a protozoölogist who, at the present time, undertakes a survey of either the free-living or parasitic Protozoa of the Philippine Islands is essentially a pioneer, since practically no work on this subject has been done. Certain species of medical importance have been investigated with considerable care, especially the malarial parasites, the dysentery amœba, *Endamœba histolytica,* and the dysentery ciliate, *Balantidium coli,* but no doubt thousands of species, many of which are new to science, live on or within the bodies of Philippine animals. That this is true is indicated by our results presented in this paper. We have not been able to study in detail any of the organisms recorded except those that live in monkeys and the *Giardia* of the civet cat, which will be described in separate papers. It has thus been impossible for us to determine in most cases the specific identity of the Protozoa found, but we hope that our studies may stimulate further investigations.

PROTOZOA OF MAN

Although our observations have been devoted almost entirely to the Protozoa of the lower animals, we have made a few observations on the Protozoa of human beings. During a visit to Olongapo, Zambales, we obtained fresh fæcal samples from thirteen Negritos and examined them at once.[2] Slides were also prepared for future study. We found that every one of the thirteen was infected with hookworms and amœbæ and that four of them were infected with *Trichomonas hominis. Endamœba coli* was present in every individual and *Endolimax nana* in seven of them.

No adequate survey has been made of the parasites of the non-Christian tribes living in the Philippine Islands, and more careful studies of Christian Filipinos are very desirable. At least one hundred individuals of each type should be taken as a sample, and fæcal and blood examinations for Protozoa and worms should be made. The results should be considered in

[2] We are indebted to Mr. de Aro and Mrs. John Gordon, of Olongapo, for making it possible for us to obtain this material.

connection with the character of the food and habits of the people that might have an influence on the transmission and reproduction of the parasites.

PROTOZOA OF MONKEYS

For purposes of classroom material and of research the Protozoa of monkeys are peculiarly valuable. The studies of many investigators have revealed that morphologically the Protozoa that live in monkeys are indistinguishable from those that live in man. They are also similarly located. An autopsy on a monkey affords even better material for study than an autopsy on a human being since monkeys are more frequently infected with a large number of species than are human beings. This, at least, is true of the monkeys that we have examined from Luzon. A suggested plan of procedure is first to obtain samples of blood from the living monkey; this can most easily be accomplished by snipping off the end of the tail. A drop of living blood should be spread out under a cover glass and examined at once to detect trypanosomes or any other active, blood-inhabiting Protozoa, and several films should be made and stained with Giemsa for later examination for malarial parasites and babesias, both of which have been reported from monkeys. A sample of fresh blood is particularly valuable since an active trypanosome can easily be found, whereas if only one or two trypanosomes are present on a stained film they can be located only after tedious search. Blood films in the Tropics should be dried and fixed with absolute methyl alcohol as soon as possible in order to prevent hæmolysis.

The monkey should next be chloroformed and fastened to an operating board. The tissues at the sides of the mouth may then be cut down and the jaws held open with a glass slide. The mouths of monkeys are usually in a very dirty condition and it is not surprising to find amœbæ and trichomonads in material obtained by scraping the gingival spaces at the base of the teeth with a small scalpel. This material should be spread out in saline solution under a cover glass. Trichomonads are conspicuous as they swim about with jerky movements; they can be seen with the low-power objective (16 mm). After some experience amœbæ can also be located under low magnification; their locomotion can best be observed with the high dry objective (4 mm) or under the oil-immersion lens. After the pre-

paration has been examined for living Protozoa the cover glass may be removed and the liquid allowed to evaporate until the smear is almost dry. Then it may be plunged into hot Schaudinn's solution and later stained with iron hæmatoxylin. If too much liquid remains on the slide everything will be washed off when placed in the fixative.

The abdominal wall of the monkey should now be opened and the entire intestine removed, as well as the spleen, urinary bladder, and vagina, if the monkey is a female. If the spleen is enlarged or dark the monkey was probably suffering from malaria. A tissue smear from the spleen should be made, dried, and cleared with immersion oil; this is sufficient to reveal the presence of the pigment granules characteristic of malaria. Trichomonads have been recorded from the vagina of monkeys (Hegner and Ratcliffe, 1927) and have been found by us in the vagina of Philippine monkeys. The inner wall of the vagina should be scraped gently and the material examined in saline solution on a slide. Trichomonads have also been recorded from the urinary bladder of men, but never from this organ in monkeys. They should be looked for, however, since it seems probable that they will eventually be found in the monkey.

A large number of Protozoa should be expected in the intestine. The duodenum is the optimum habitat of flagellates of the genus *Giardia;* these organisms and their cysts should also be searched for in the jejunum and ileum. A number of investigators have reported giardias from the bile ducts and gall bladder. These locations should be examined in monkeys that are found to be infected with these flagellates.

Another type of protozoan that lives in the small intestine of several of the lower animals is the coccidium. Coccidia have been reported from man in about two hundred cases but never from monkeys. Only the stages that occur in the oöcyst of *Isospora hominis* from man are known. We must construct the stages within the human body from what we know of the life cycle of *Isospora felis* in cats. If coccidia occur in monkeys they will eventually be found, and an opportunity will then be afforded to determine the stages that take place in the internal organs. The most conspicuous stage is the oöcyst, which is a body easily recognized and sufficient to indicate an infection. Care should be observed, however, not to accept oöcysts as evidence of infection until it has been determined that the oöcysts were produced within the body of the monkey and are

not parasites of other animals that had been swallowed by the monkey and were on their way through the intestine.

The large intestine of man and of the monkey furnishes a habitat for amœbæ, flagellates, and ciliates. Five types of amœbæ apparently belonging to species living in man have been recorded from monkeys; these are *Endamœba histolytica, E. coli, Endolimax nana, Iodamœba williamsi,* and *Dientamœba fragilis.* One or several of these are usually to be found in every monkey examined. In some cases the identity of the amœba can be determined from the living specimen, but often smears must be fixed and stained and the nuclear structure determined before the species is certain. Trophozoites seem to be most numerous in the cæcum, and cysts in the posterior part of the colon. The number of nuclei in cysts can be determined by adding a drop of a 5 per cent aqueous solution of potassium iodide saturated with iodine to the material under the cover glass. This stains the nuclei. One human intestinal amœba, *Dientamœba fragilis,* which has not been heretofore reported from monkeys, was found by us in two individuals. It has been recorded in less than one hundred human cases and is evidently rare in man as well as in monkeys.

The flagellates that are recognized as inhabitants of the large intestine of man have also been recorded from monkeys. These include *Trichomonas hominis, Chilomastix mesnili, Embadomonas intestinalis,* and *Tricercomonas intestinalis.* Trophozoites are more likely to be found in the cæcum than in the colon. All but *Trichomonas hominis* are known to form cysts; these should be sought in the lower colon.

A single species of ciliate, *Balantidium coli,* occurs in the large intestine of man, and is supposed to be the same as the species that lives in pigs and monkeys. It seems to be more numerous in the appendix of the monkey than in any other region. Three species of ciliates of the genus *Troglodytella* have been reported from the intestines of chimpanzees and gorillas but have not been found in other species of monkeys or in man.

It seems evident from the above description that monkeys offer excellent material, especially for the study of intestinal Protozoa (including those occurring in the mouth and vagina). We have found that monkeys recently captured are as frequently and as heavily infected as are specimens that have been in captivity for long periods. Efforts have been made to determine by exact measurement whether the Protozoa of monkeys and man are morphologically alike. The results indicate that

they are (Hegner and Chu, 1930). Cross-infection experiments are necessary before it can be stated definitely that they really belong to the same species. Many of them have been grown in artificial media, in which they exhibit characteristics that are comparable to those of human species. In some cases the intestinal Protozoa of monkeys are too few to furnish satisfactory material for the permanent slides necessary for identification. It is suggested that samples of intestinal contents be injected into the rectum of parasite-free young chicks; certain Protozoa grow and multiply rapidly in the cæca of the chick, thus furnishing an abundance of material for study (Hegner, 1929).

The following are the Protozoa observed by us in forty-four wild monkeys and the number of individuals infected by each:

	Monkeys infected.
Endamœba histolytica	10
Endamœba coli	22
Endamœba gingivalis	37
Endolimax nana	22
Dientamœba fragilis	2
Giardia lamblia	6
Trichomonas hominis	37
Trichomonas buccalis	36
Trichomonas vaginalis	2
Chilomastix mesnili	15
Balantidium coli	8

Most of our material was studied in the living condition only, hence this list cannot be considered complete. In several monkeys small flagellates were observed that resembled *Embadomonas, Tricercomonas,* and *Hexamita.* No specimen that could definitely be determined as *Iodamœba* was observed, although some would probably have been found if prepared slides were made from all of the monkeys. No coccidium or blood-inhabiting species was encountered.

As noted in another paper (Hegner, 1928) the study of monkey Protozoa has brought out an interesting point of biological significance. When two species of animals are parasitized by the same species a close relationship between the hosts is assumed. If this is applied to the protozoan parasites of monkeys and man a very close relationship between these two hosts is evident. This similarity of protozoan parasites indicates close kinship of man and monkeys and adds another type of evidence that man and monkeys have descended from a common ancestor.

PROTOZOA OF TARSIUS

Four living specimens of *Tarsius fraterculus* were obtained from Bohol Island. Every one of them had intestinal infections with amœbæ and trichomonads.

PROTOZOA OF OTHER MAMMALS

Many species of both blood-inhabiting and intestinal Protozoa have been described from domestic, laboratory, and wild mammals. Our observations indicate that these mammals are parasitized by the same types of Protozoa in the Philippines as in other countries.

Carabao.—The carabao, or water buffalo, is the common draft animal in the Philippines; its milk is used for food and its flesh takes the place of beef among many of the Filipinos. Protozoa, particularly ciliates, are abundant in the first and second stomachs (rumen and reticulum) of the carabao just as they are in cattle in other countries. We obtained material containing enormous numbers from carabaos slaughtered in Manila. No attempt was made to determine species, since this would require more time than was at our disposal. Becker and Talbott (1927) have reported on the Protozoa in the stomach of cattle and list two species of amœbæ, five species of flagellates, and thirty-nine species and varieties of ciliates. Besides these, many species of Protozoa have been recorded from the intestine of cattle including amœbæ, *Giardia, Trichomonas, Balantidium,* and coccidia. Among the blood-inhabiting Protozoa reported from cattle are babesias, *Plasmodium,* and trypanosomes. Sarcosporidia have also been found in the muscle of cattle. We did not examine the blood and intestine of the carabao for Protozoa. This animal offers attractive material for study.

Pig.—One of the most interesting protozoan parasites of the pig is the ciliate *Balantidium coli.* This species was found in the large intestine of pigs slaughtered in Manila. It also lives in the wild pigs that occur in the forests of the Philippines, as was demonstrated by the presence of many specimens in the one host available for study. We did not determine whether the balantidia of the domestic pigs of Manila and of the wild pig are of the *coli* type, *suis* type, or of both types (McDonald, 1922). Pigs are known to be infected with various species of intestinal amœbæ, flagellates, and coccidia, with blood-inhabiting trypanosomes and babesias, and with muscle sarcosporidia.

Dog.—Portions of the digestive tract of twelve dogs obtained from the department of physiology were examined by us. *Giardia canis* was found in the duodenum of one specimen and trichomonad flagellates in the large intestine of another specimen. No protozoan was noted in the mouth of four of the dogs and in the vagina of two. A more thorough study would probably reveal many more species, since dogs are known to harbor intestinal amœbæ, flagellates, and coccidia as well as blood-inhabiting babesias, leishmanias, and trypanosomes, and tissue-inhabiting *Sarcocystis*.

Rabbits.—Amœbæ, flagellates, and coccidia have been reported from rabbits. The amœba *Endamœba cuniculi* does not appear to be commonly present. Among the flagellates described by various investigators are *Giardia duodenalis, Chilomastix cuniculi, Trichomastix cuniculi, Embadomonas cuniculi,* and *Enteromonas intestinalis.* The most frequently present of all rabbit Protozoa are the coccidia. These are tissue-invading organisms and thus pathogenic, often bringing about the death of the host.

Laboratory rabbits maintained by the College of Medicine, University of the Philippines, were found to be well infected with coccidia. Rabbits are inhabited by at least two species of these Protozoa; namely, *Eimeria stiedae,* in the tissues of the liver, and *E. perforans,* in the intestinal wall. The fæcal pellets of infected rabbits should be softened in water and a small amount placed on a slide for examination. The oöcysts of *Eimeria stiedae* are ellipsoid or ovoid, flattened at one pole, and usually from 35 to 40 microns long and 23 to 28 microns broad. Stages in the formation of four sporoblasts within each oöcyst and of two sporozoites within each sporoblast may be observed in living specimens, if infected fæcal material is kept moist for a few days. If material is placed in a 5 per cent solution of potassium bichromate the growth of fungi and bacteria is retarded. Stages in the asexual cycle of *E. stiedae* may be obtained for study by fixing, sectioning, mounting, and staining tissue from the liver of an infected rabbit.

There is evidence in the literature on the coccidia of the rabbit that more than two species may be present (Kessel and Junks, 1929). In the fæcal pellets studied by us what appeared to be three types of oöcysts were present. One type resembles *Eimeria stiedae* in shape and size (Plate 1, figs. 4, 5, and 6). They were oval and averaged 35 microns in length and 23 microns

in breadth. The micropyle was conspicuous and broad. A second type appeared to be *E. perforans* (figs. 7, 8, and 9). Its oöcysts were also oval; they averaged 24 microns in length and 16 microns in breadth. The micropyle is not well marked, there being only a slight thinning of the wall at one end. The sporoblasts are at first spherical but later, when the sporozoites develop, become elongated. A spherical residual body is present. The third type (figs. 1, 2, and 3) is narrower at one end than at the other, has a well-defined but narrow micropyle, and is intermediate in size between the other two. It averages 31 microns in length and 19 microns in breadth. Four sporoblasts are formed and a residual body occurs. This type was more abundant than either of the other two in our material. Besides coccidia, *Giardia* and *Trichomastix* were encountered in the duodenum and colon, respectively, of the rabbits we examined.

Guinea pig.—Among the intestinal Protozoa that are frequently present in guinea pigs are flagellates, ciliates, amœbæ, and coccidia. *Giardia caviae* may be found in the duodenum, and the other species in the cæcum. Trichomonads are usually present in large members; *Chilomastix intestinalis* is a well-known species; *Embadomonas* has been described by several investigators; *Balantidium caviae* sometimes occurs in the cæcum (Scott, 1927); *Eimeria caviae* is fairly common in the large intestine (Sheather, 1924); *Endamœba cobayae* is a *coli*-like amœba with eight-nucleated cysts (Holmes, 1923) that may be encountered in the cæcum or colon; and *Endolimax caviae* (Hegner, 1926) is likewise an inhabitant of the cæcum. Infection with intestinal Protozoa evidently takes place among guinea pigs as a result of association, since if one member of a group that have lived together is infected with a certain species the other members are usually infected also.

The cæcum of guinea pigs is often very heavily infected with *Trichomonas caviae* Davaine, 1875. This species is one of the best for study because of its large size; many specimens in the cæcum of the two guinea pigs examined by us measured up to 25 microns in length and 12 microns in breadth. Enormous variation occurs in the size of guinea-pig trichomonads; specimens as small as 8 microns in length and 4 microns in breadth were also abundant. Whether more than one species are represented in guinea pigs is still in doubt. Faust (1921) believes he found differences of specific rank among trichomonads from

guinea pigs in Peking and described a species as *T. flagelliphora.* Cysts have been described and what appeared to be cysts were seen by the writers in the colon of the two guinea pigs examined. Whether more than one species of *Trichomonas* occur in guinea pigs is a problem that requires detailed cytological and experimental study. Perhaps the experimental infection of chicks would be helpful in determining this point (Hegner, 1929).

Rat.—Laboratory rats are of great value to protozoölogists as sources of material, as experimental animals, and as reservoirs for the maintenance of certain types of Protozoa. Among the intestinal Protozoa the following can almost always be obtained if half a dozen rats are examined: *Giardia muris* in the duodenum, *Hexamita muris* in the ileum, and *Trichomonas muris, Chilomastix bettencourti,* and *Endamœba muris* (fig. 53) in the cæcum or colon. Wild rats do not seem to be as highly parasitized with Protozoa as laboratory rats, but one of the best known of the trypanosomes, *T. lewisi,* occurs in them and is easily transferred to the latter. The laboratory rats that we have examined in Manila were found to contain specimens of all of the intestinal Protozoa listed above. No study was made of wild rats.

Civet cat.—Civet cats are common in certain regions of the Philippine Islands and can be obtained alive from the natives. Fæces collected by us in paths in the forest were found to contain large numbers of amœbæ and flagellates, probably coprozoic species. One living animal was anæsthetized in the laboratory; no blood-inhabiting protozoan was found in it, but giardias and coccidia were discovered in the duodenum. The giardias, when stained, obviously differed in specific characteristics from those that have been reported from other animals and are being studied in detail and will be fully described in a separate publication (Chu, 1930).

Bat.—Bats are abundant in the Philippines, and many species are available for study. They are not very heavily parasitized. This is probably due, so far as intestinal Protozoa are concerned, to the fact that they are continuously on the wing when away from their resting places, and, even when they are at rest, their fæces drop to the ground where their bodies never come in contact with them; thus contamination by contact with fæcal material must be infrequent and hence transmission difficult. Blood-inhabiting Protozoa, which are transmitted by blood-sucking arthropods, are no doubt frequently inoculated into bats

by their intermediate hosts. Therefore, it is not surprising that bats are more often reported to be infected with babesias, malarial parasites, and trypanosomes than with intestinal Protozoa. We collected bats from buildings in Manila and from caves and buildings within a radius of about 75 kilometers of Manila. Specimens were obtained from Paete, Teresa, Talisay, Sibul Springs, and Imus. These included the large fruit bat and small bats, both fruit bats and insectivorous bats. Over forty specimens were examined but no protozoan parasites were observed in the blood, and the only intestinal Protozoa found were coccidia of the genus *Eimeria* obtained from two specimens of an insectivorous species collected in a cave near Sibul Springs; ten specimens of this parasite ranged from 19 to 21 microns in length and from 17 to 20 microns in breadth; the average size was 20.7 by 18.9 microns. Plate 1, fig. 10, represents an oöcyst with a large residual body; fig. 11 was drawn one week later, at which time the residual body had almost entirely disappeared and the spores had become more fully developed.

Flying lemur.—Two living specimens of *Cynocephalus volans* were obtained from Bohol Island. The cæcum contained at least two species of flagellates; these were not studied in detail.

PROTOZOA OF BIRDS

Both domesticated and wild birds are frequently infected with blood-inhabiting and intestinal Protozoa. The Protozoa of the domestic fowl, pigeon, duck, goose, guinea hen, etc., have not been studied very carefully, but amœbæ, flagellates, and Sporozoa have been described from them. The Protozoa of wild birds are very little known but would well repay investigation. Of the domesticated birds we have recorded Protozoa from the fowl and pigeon. It was our intention to use chicks as "living test tubes" (Hegner, 1929) in this and in other phases of our work, but difficulties in obtaining a sufficient supply prevented it. The wild birds examined by us were, with few exceptions, shot in the field. Blood films were made at once but only in about half of the cases were examinations of the intestinal contents made. A list of the wild birds and of the types of Protozoa found in them is given in Table 1.[3]

[3] We are indebted to Mr. Richard C. McGregor, of the Bureau of Science, for identifying many of these species for us. The family and species names have been taken from McGregor's Manual of Philippine Birds, Manila (1909).

TABLE 1.—*Wild Philippine birds and the Protozoa found in them.*

Family and species.	Common name.	Date.	Locality.	Protozoa found.
TRERONIDÆ		*1929*		
Osmotreron axillaris	Philippine green pigeon	Aug. 24	Cavite	None.
Phapitreron leucotis	Northern white-eared pigeon.	Aug. 24	do	Do.
Geopelia striata	Barred ground dove	Aug. 24	do	Do.
Do	do	Sept. 6	Obando	Do.
Leucotreron leclancheri	Black-chinned fruit pigeon.	Oct. 25	Dasmariñas	Do.
RALLIDÆ				
Gallinula chloropus	Moorhen	Sept. 3	Pateros	Do.
LARIDÆ				
Sterna sinensis	White-shafted tern	Oct. 11	Paete	Do.
Do	do	Oct. 11	do	Do.
Do	do	Oct. 11	do	Do.
Do	do	Oct. 11	do	Do.
CHARADRIIDÆ				
Aegialitis alexandrina	Kentish plover	Oct. 4	Rosario	*Trichomonas.*
Actitis hypoleucos	Common sandpiper	Sept. 6	Obando	Do.
Gallinago stenura	Pintail snipe	Oct. 11	Paete	Do.
ARDEIDÆ				
Bubulcus coromandus	Indian cattle egret	Sept. 17	Talisay	*Giardia.*
Do	do	Sept. 20	Marilao	Do.
Do	do	Sept. 20	do	Do.
Do	do	Oct. 22	Lemery	None.
Do	do	Oct. 22	do	Do.
Ixobrychus sinensis	Little yellow bittern	Sept. 3	Pateros	*Haemoproteus.*
Do	do	Oct. 11	Paete	Do.
Do	do	Sept. 6	Obando	Do.
Ixobrychus cinnamomeus	Cinnamon bittern	Sept. 13	Angono	Do.
FALCONIDÆ				
Accipiter manillensis	Philippine sparrow hawk	Sept. 17	Talisay	Do.
Haliastur intermedius	Malayan Brahminy kite	Oct. 16	Lubao	Coccidia.
Do	do	Sept. 17	Talisay	Do.
Microhierax erythrogenys	Philippine falconet	Oct. 25	Dasmariñas	Do.
PSITTACIDÆ				
Bolbopsittacus lunulatus	Luzon guaiabero	Aug. 24	Cavite	Do.
CORACIIDÆ				
Eurystomus orientalis	Broad-billed roller	Sept. 26	Dasmariñas	*Haemoproteus.*
Do	do	Sept. 24	Arayat	None.
ALCEDINIDÆ				
Halcyon coromandus	Ruddy kingfisher	Sept. 24	do	Coccidia.
Halcyon gularis	White-throated kingfisher			
Halcyon chloris	White-collared kingfisher	Sept. 13	Angono	None.
Do	do	Sept. 13	do	Do.
Do	do	Sept. 6	Obando	Do.
Halcyon lindsayi	Lindsay's kingfisher	Sept. 14	Talisay	*Haemoproteus.*
Do	do	Sept. 24	Arayat	None.

TABLE 1.—*Wild Philippine birds and the Protozoa found in them*—Ctd.

Family and species.	Common name.	Date.	Locality.	Protozoa found.
BUCEROTIDÆ		*1929*		
Penelopidis manillae	Luzon tarictic	Sept. 17	Talisay	None.
MEROPIDÆ				
Merops philippinus	Green-headed bee-bird	Oct. 11	Paete	Do.
MICROPODIDÆ				
Collocalia troglodytes	Pigmy swiftlet	Sept. 14	Talisay	Do.
Do	do	Sept. 14	do	Do.
Collocalia marginata	Salvadori's swiftlet	Sept. 26	Dasmariñas	Do.
Tachornis pallidior	Paler palm swift	Sept. 14	Talisay	Do.
CUCULIDÆ				
Centropus javanicus	Java coucal	Aug. 24	Cavite	*Haemoproteus.*
PICIDÆ				
Yungipicus validirostris	Large-billed pigmy woodpecker.	Sept. 26	Dasmariñas	None.
Lichtensteinipicus funebris.	Funereal woodpecker	Sept. 14	Talisay	Do.
HIRUNDINIDÆ				
Hirundo gutturalis	Eastern swallow	Oct. 14	Rosario	Do.
CAMPOPHAGIDÆ				
Edolisoma caerulescens	Luzon cuckoo shrike	Sept. 24	Arayat	Do.
Lalage niger	Pied lalage	Sept. 24	do	Coccidia.
Do	do	Sept. 24	do	Do.
PYCNONOTIDÆ				
Iole gularis	Philippine bulbul	Oct. 30	Dasmariñas	*Haemoproteus.*
Do	do	Oct. 1	Teresa	Do.
Do	do	Oct. 1	do	Do.
Do	do	Sept. 14	Talisay	*Plasmodium.*
Do	do	Sept. 9	Dasmariñas	None.
Pycnonotus goiavier	Guava bulbul	Oct. 1	Teresa	Do.
Do	do	Aug. 24	Cavite	Do.
TURDIDÆ				
Practincola caprata	Pied chat	Aug. 23	Novaliches	Do.
Do	do	Aug. 23	do	Do.
LANIIDÆ				
Cephalophoneus nasutus	Large-nosed shrike	Sept. 13	Angono	*Plasmodium.*
Do	do	Sept. 13	do	None.
Do	do	Aug. 24	Cavite	Do.
Otomela lucionensis	Gray-headed shrike	Oct. 30	Dasmariñas	Coccidia.
Do	do	Aug. 6	Novaliches	Coccidia, *Plasmodium.*
Do	do	Aug. 6	do	Coccidia.
Do	do	Aug. 6	do	Do.
Do	do	Aug. 6	do	Do.
Do	do	Aug. 6	do	Do.
Do	do	Aug. 6	do	Do.
Do	do	Sept. 13	Angono	None.
Do	do	Sept. 20	Sibul springs	Do.

TABLE 1.—*Wild Philippine birds and the Protozoa found in them*—Ctd.

Family and species.	Common name.	Date.	Locality.	Protozoa found.
MOTACILLIDÆ		*1929*		
Motacilla melanope	Streak-eyed wagtail	Oct. 4	Rosario	None.
Do	do	Oct. 4	do	Do.
Do	do	Sept. 26	Dasmariñas	Do.
ALAUDIDÆ				
Passer montanus	Mountain sparrow	Aug. 13	Manila	Coccidia.
Do	do	Aug. 13	do	Do.
Do	do	Aug. 13	do	Do.
Do	do	Aug. 13	do	Do.
Do	do	Aug. 13	do	None.
PLOCEIDÆ				
Padda oryzivora	Java sparrow	Aug. 23	Paombong	Do.
Do	do	Aug. 23	do	Do.
Do	do	Aug. 26	Muntinlupa	Coccidia.
Do	do	Aug. 26	do	None.
Munia jagori	Philippine weaver	Aug. 23	Paombong	Do.
Do	do	Aug. 23	do	Do.
Do	do	Sept. 3	Pateros	Do.
Munia cabanisi	Cabanis's weaver	Sept. 3	do	Do.
ORIOLIDÆ				
Oriolus acrorhynchus	Philippine oriole	Sept. 9	Dasmariñas	*Haemoproteus.*
Do	do	Sept. 9	do	Do.
Do	do	Sept. 9	do	None.
STURNIDÆ				
Sturnia sinensis	Gray-backed starling	Oct. 25	Dasmariñas	*Trichomonas,* Coccidia.
Do	do	Oct. 25	do	Do.
Do	do	Oct. 25	do	Do.
Æthiopsar cristatellus	Crested myna	Sept. 24	Arayat	Do.
Sarcops calvus	Gray-backed coleto	Oct. 15	Dasmariñas	*Haemoproteus.*
CORVIDÆ				
Corone philippina	Philippine crow	Sept. 17	Talisay	None.

Blood-inhabiting Protozoa of birds.—Protozoa of the genera *Hepatozoon, Haemoproteus, Leucocytozoon, Plasmodium, Toxoplasma,* and *Trypanosoma* have been recorded from the blood of birds. Those most frequently present belong to the genera *Haemoproteus* and *Plasmodium.*

The genus Haemoproteus.—Species belonging to this genus have been reported from large numbers of birds and from turtles and lizards. The fact that they grow around the nucleus of the red cell and become shaped like a halter, instead of pushing the nucleus to one side as do the parasites of bird malaria, prompted Labbé (1894) to propose the genus name *Halteridium* for this type. However, the name *Haemoproteus* has priority.

The best-known species is *Haemoproteus columbae* of the pigeon. The fly *Lynchia maura* is the transmitting agent of this species, and developmental stages similar to those of the malarial organism in mosquitoes occur in this fly. Other agents must be responsible for transmission to pigeons in certain areas and to other birds since the parasites occur in birds that live in areas where *Lynchia maura* does not exist. It is of interest to note that the observation of MacCallum (1897) of the formation of microgametes and subsequent fertilization of macrogametes of *Haemoproteus* led him (MacCallum, 1898) to look for and find a similar process in the gametocytes of human malaria.

Haemoproteus was found in the blood of seven of the forty-seven species and ninety-five individual birds examined by us as shown in the accompanying list. Unlike malarial parasites, no asexual stages occur in the peripheral blood, this stage in the life cycle being passed through in the endothelial cells of the blood vessels. Thus only gametocytes are to be found in blood films. How many species of *Haemoproteus* are represented in our material has not been determined. Plate 2, figs. 19 to 35, shows camera lucida drawings of a few of the parasites and gives some idea of their characteristics.

The genus Plasmodium.—Species of the genus *Plasmodium* have been described from birds in various parts of the world, and some of the most important work on malaria has resulted from the study of this disease in birds.

How many species of *Plasmodium* occur in birds is not known. For many years the name *Plasmodium praecox* was employed to designate all parasites of this type reported from birds. Recently, however, Hartman (1927) has recognized three distinct species that occur in English sparrows in the eastern United States, and probably other species of *Plasmodium* exist in this and other species of birds. Bird malarial organisms are favorable for experimental studies because they can be inoculated easily into canaries. Canaries grown in captivity are free from malarial parasites. They can be inoculated easily by drawing into a small syringe containing a little normal saline solution, a few drops of blood from an infected bird and injecting this into the breast muscle or peritoneal cavity of a fresh canary. As a rule parasites begin to appear in the blood of this bird in about five days; the maximum number of parasites are present five days later and parasites disappear from the blood at the end of about five days more. That parasites are still present in the

blood is evident since the blood of a bird at this stage when inoculated into a fresh bird will bring about an infection. They are so few in number, however, that they cannot be found by routine methods of examination but only after exhaustive searching. Apparently, in most cases, a bird once infected remains infected throughout its life (Hegner, 1929).

The characteristics that have been used to distinguish species of bird malarial organisms are length of the asexual cycle; presence or absence of schizonts in the peripheral blood; shape and size of the gametocytes and trophozoites; staining reactions of the gametocytes and trophozoites; the number, size, shape, and distribution of pigment granules; the number of merozoites; and the number of parasites per given number of red blood corpuscles (see Hartmen, 1927).

Malarial parasites were found in only three birds. Typical specimens are illustrated on Plate 3, figs. 39 to 46. The species found in the gray-headed shrike (fig. 45) seems to have larger pigment granules than any heretofore recorded for *Plasmodium* in birds, but we are not prepared at present to pronounce it a new species. The small number of infections found (3 in 95 birds) appear to indicate a low incidence of infection. However, it should be remembered that the acute stage of the infection lasts for only a few days (about ten days in the canary) and that after the end of the acute stage so few parasites remain in the blood stream that they are extremely difficult to find. It seems probable, therefore, that many infections were not found. Perhaps the inoculation of blood from these birds into parasite-free canaries would have revealed infections that escaped discovery. This method should be employed in any intensive study of this subject.

Intestinal Protozoa of birds.—Various species of amœbæ, flagellates, and coccidia live in the intestines of birds. Among those most frequently encountered are trichomonads and coccidia. The coccidia penetrate the intestinal wall and develop at the expense of the tissue cells. Their presence is indicated by the discovery of oöcysts in the fæces. Several species of coccidia may inhabit a single individual, the species differing in their distribution within the tissues of the digestive tract (Tyzzer, 1929), being located in the duodenum or cæcum or colon. The amœbæ and flagellates of birds are mostly restricted to the cæca and are therefore to be found most frequently in birds that possess well-developed cæca.

Protozoa of fowls.—Intestinal Protozoa of birds are most easily obtained from domestic fowls. Two species of trichomonads were described from fowls by Martin and Robertson (1911); namely, *Trichomonas eberthi* with three anterior flagella, and *T. gallinarum* with four anterior flagella. These investigators also described *Chilomastix gallinarum*. *Endamœba gallinarum* was reported from fowls by Tyzzer (1920) and *Endolimax gregariniformis* by Tyzzer (1920) and by Hegner (1926). These are all inhabitants of the cæcum. Coccidia have been known to occur in fowls for over seventy years and are of common occurrence. The name *Eimeria avium* has been applied to these coccidia, but the recent work of Tyzzer (1929) indicates that the domestic fowl may be parasitized by as many as three species.

We did not attempt to make an exhaustive study of fowl Protozoa. Two young pullets were examined; the cæca of one contained an abundance of trichomonads, a few individuals of *Chilomastix*, and a few of *Endamœba;* the cæca of the other were almost empty, but numerous trichomonads were present, a few specimens of *Endolimax*, and a few coccidia. The trichomonads varied considerably in size; it was impossible to distinguish species from the living specimens, but both of the species recognized by Martin and Robertson may have been present. The *Chilomastix* was probably *C. gallinarum*. The *Endamœba* corresponded in size and characteristics to *E. gallinarum;* it measured in the living condition about 28 microns in length and 20 microns in breadth (Plate 4, fig. 50). The *Endolimax* resembled *E. gregariniformis;* it was about 15 microns long and 7 microns broad (fig. 52). The oöcysts of the coccidia found were unsegmented; they no doubt belonged to the genus *Eimeria*. One may confidently expect to find specimens of *Trichomonas, Chilomastix, Endamœba, Endolimax*, and *Eimeria* in the cæca of fowls if several birds are examined.

Pigeon.—The pigeon is the host of a coccidium named *Eimeria pfeifferi*, and a high incidence of infection has been noted. One pigeon that we examined contained large numbers of oöcysts. Measurements of fifty specimens are presented in Table 2.

Table 2 shows a high degree of correlation between length and breadth. These oöcysts are smaller than those described by Nieschulz (1921), who gives their size as 14 to 24 microns in breadth and 15 to 26 microns in length.

Wild birds.—No amœbæ and only two types of flagellates were found in the intestines of the wild birds we examined.

TABLE 2.—*Correlation of measurements of fifty oöcysts of Eimeria pfeifferi from a pigeon.*

Breadth of oöcysts in microns.	Length of oöcysts in microns.						
	13	14.3	15.6	16.9	18.2	19.5	
11.7	2	1					3
13.0	4	3	4				11
14.3		4	4	2	1		11
15.6				9	5	1	15
16.9				5	3	2	10
Total	6	8	8	16	9	3	50

Trichomonas occurred in the Kentish plover, common sandpiper, and gray-backed starling, and *Giardia* was present in three of five specimens of the Indian cattle egret. No detailed study was made of the trichomonads. The giardias of birds are taxonomically in a confused state at present (Hegner, 1925).

Wild birds are not as heavily infected with intestinal Protozoa as are domestic fowls. Those most frequently encountered are coccidia of the genera *Eimeria* and *Isospora*. The list of birds that we examined indicates only partially to what extent one may expect to find coccidia in wild birds, since not more than half of these birds were examined for coccidia. Seven species were positive. Apparently those most often infected are the pied lalage, gray-headed shrike, mountain sparrow, and gray-backed starling. Some of the intestinal material containing coccidia was placed in potassium bichromate solution and their development followed. All proved to belong to the genus *Isospora,* but we made no attempt to determine whether or not we were dealing with new species. The oöcysts from the crested myna (Plate 1, fig. 14) were almost spherical and contained two pear-shaped spores and a very small residual body. Ten specimens ranged from 22 to 27 microns in diameter; the average diameter was 23.8 microns. A slight bulge where the oöcyst wall was a little thinner than elsewhere indicates the position of the micropyle. The oöcysts from the pied lalage were oval and also contained two pear-shaped spores and a small residual body (fig. 15). The position of the micropyle at one end could be determined by the thinner wall of the oöcyst. Ten specimens ranged from 21 to 24 microns in breadth and from 24 to 28 microns in length with an average breadth of 22.9 microns and an average length of 27.5 microns. What are probably two species were found in the gray-backed starling. One species

was oval and about 23 microns in diameter, and the other oval and about 21 microns broad and 27 microns long. No residual mass was noted in the oöcyst. The oöcysts found in the brahminy kite were of various shapes due to the thinness of the wall and different positions of the spores within. Three specimens measured 13 by 18 microns, 16 by 18 microns, and 12 by 21 microns, respectively. In the ruddy kingfisher were found spores with a knoblike process at either end. They measured 13 by 25 microns. An immature spore is shown in fig. 12 and a spore drawn six days later is shown in fig. 13, both on Plate 1.

PROTOZOA OF REPTILES

Reptiles of various types, turtles, snakes, lizards, and crocodiles are inhabited by various species of both blood-inhabiting and intestinal Protozoa. We have examined only a few specimens of Philippine reptiles. In every case the blood was negative, but in many specimens intestinal Protozoa were found.

Turtle.—One specimen of *Cyclemys amboinensis* that had been in captivity in Manila was free from Protozoa.

Python.—One python, *Python reticulatus,* captured at Montalban had trichomonads and coccidia (Plate 1, figs. 16 and 17) in the intestine. The trichomonads were cultivated successfully at room temperature in serum-saline-citrate medium and positive subcultures obtained.

Iguana.—Six specimens of the species *Hydrosaurus pustulosus* were shot at Talisay. Every one was found to contain trichomonads in the intestine.

Lizards.—All of five lizards of the species *Mabuya multicarinata* had both trichomonads and coccidia in the intestine.

PROTOZOA OF AMPHIBIA

Frogs.—Frogs are well supplied with Protozoa. Among the commoner blood-inhabiting species are trypanosomes, hæmogregarines, and *Cytamœba.* The intestinal species that are frequently present belong to the genera *Balantidium, Endamœba, Hexamita, Nyctotherus, Opalina,* and *Trichomonas.* Other genera are not encountered as often. It is thus evident that frogs are important animals from which to obtain material for study and research. *Trypanosoma rotatorium,* which occurs in the blood plasma, is the type species of its genus. The opalinids are large ciliates that are of particular interest because of their use by Metcalf (1923) for studies of host relationships. A number of species of *Balantidium* have been described from

frogs from various parts of the world. The trichomonads of frogs fix and stain beautifully which makes them useful for students, since species from certain other animals, including man, can be well stained only with difficulty. Frog tadpoles are also usually heavily infected with intestinal Protozoa. Many of these are of the same species as those living in the adults, but both *Giardia agilis* and *Euglenamorpha hegneri*, occur in tadpoles only, and in certain species of frogs the opalinids are lost at the time of metamorphosis. An ectoparasitic ciliate, *Trichodina pediculus*, sometimes may be found on the surface of the body of tadpoles.

The Opalinidæ are among the ciliates most easily obtained for study. Most of them occur in the rectum of frogs, toads, and tadpoles. Material from the rectum of freshly killed animals usually contains large numbers of specimens. According to Metcalf (1923) four genera are included in the family Opalinidæ; these are *Protoopalina*, which is cylindrical and binucleate; *Zelleriella*, which is flattened and binucleate; *Cepedea*, with a cylindrical form and many nuclei; and *Opalina*, with a flattened form and many nuclei. In his monograph on the Opalinidæ Metcalf (1923) states that up to that time twenty-five species had been described, two of which were doubtful. He added one hundred twenty species, of which eighteen were somewhat doubtful; twenty subspecies, of which six were doubtful; and ten forms. Other species have been described since this monograph was published. Anyone who wishes to study the many fascinating problems presented by this group of ciliates should first consult the above-mentioned monograph as well as more-recent literature by Metcalf and others.

In Taylor's (1921) monograph on the amphibians and turtles of the Philippine Islands, sixty-six species of amphibians are described, which according to Taylor include probably not more than one-half of those that exist in the Islands. Among these there are only three species that are listed by Metcalf (1923) as hosts of opalinas; these are *Bufo melanostictus*, *Rana erythraea*, and *R. tigerina*. It is thus evident that a large field is open for students of the Opalinidæ in the Philippines. Opalinas may be obtained not only from freshly killed hosts but also from animals that have been preserved in alcohol for many years. A slit may be made in the abdomen of museum specimens of amphibians, the rectum pulled out and slit, and the contents of the rectum removed. The opalinids secured in this way are often well preserved, and even the nuclear structure and chromosome num-

ber can be determined in many cases. According to Metcalf a satisfactory method of preparing specimens for study is to make a smear on a cover glass, fix in Schaudinn's solution, and stain with Delafield's hæmatoxylin, overstaining and then reducing.

Criteria of value in separating species of opalinids are the following: Shape of body; length, breadth, and thickness of body; length and distribution of cilia; width between lines of cilia at the anterior end and near the posterior end of the body; relative amounts and structure of ectoplasm and endoplasm; number of nuclei, shape, size, position in the body and position with respect to one another; and structure and number of chromosomes in the nuclei. Taxonomic studies of opalinids are accompanied by various difficulties, such as racial diversities, lack of a satisfactory method of cultivation outside of the body, differences in size and structure due to physiological conditions and stage of life cycle, and the presence of two or more species in a single host.

Besides taxonomic studies, opalinids afford excellent material for the investigation of the relationships of hosts as indicated by the presence of identical or nearly allied ciliates of this group. Metcalf has shown how effective this type of research can be, but has not had access to material from the Philippine Islands and hence a large and interesting group remains to be studied.

Our studies of frog Protozoa were limited to those of two species of hosts; namely, fourteen specimens of *Rana vittigera* and one specimen of *Kaloula picta*. A considerable number of tadpoles were examined, but the species of frogs to which they belonged was not determined. Trypanosomes were found in the blood of only one specimen of *R. vittigera*. *Trichomonas* was present in the rectum of every frog examined, often in large numbers. *Hexamita* was also a frequent inhabitant of the rectum, being present in five specimens of *R. vittigera* and in the specimen of *K. picta*. *Balantidium* was encountered in every frog. A typical living specimen from *R. vittigera* shown in fig. 36 measured 81 microns in length and 52 microns in breadth. A typical specimen of another species from *K. picta*, shown on Plate 3, fig. 47, measured 130 microns long by 102 microns broad. Opalinas of several species were found in the rectum of six specimens of *R. vittigera;* some of them measured as much as 950 microns in length. Amœbæ of two types occurred in three specimens of *R. vittigera;* these corresponded in size, shape, and locomotion to *Endamœba ranarum* and *Endolimax ranarum*

(Plate 3, fig. 38). One specimen of *R. vittigera* was infected with *Chilomastix* and another with coccidia. The tadpoles examined were free from *Giardia* and *Euglenamorpha,* but all were infected with *Trichomonas, Opalina,* and amœbæ. Many algæ were noted in the intestines of these tadpoles, but whether any of them were parasites was not determined; most of them were probably free-living species ingested with the food material. No ectoparasites were found living on tadpoles.

INTESTINAL PROTOZOA OF INSECTS

Many species of Protozoa have been described from the intestine of insects; they live either in the lumen of the intestine or in the tissues of the intestinal walls. Only a few common species of insects were examined by us; these included the housefly, cockroach, and mosquito.

Housefly.—The genus *Herpetomonas* is included in the family Trypanosomidæ. Its members are parasitic in invertebrates, mostly insects, and are transmitted from host to host in the cyst stage by the fæcal contamination of food. It has been the custom to propose a new specific name for every herpetomonad discovered in a new species of host regardless of morphological distinctions. Becker (1923) has shown by cross-infection experiments that the herpetomonads living in each of six different species of flies are infective to the other five and that probably all belong to one species.

The species most easily obtained is *Herpetomonas muscae domesticae,* the type species of the genus. It has been recorded from the intestine of houseflies in various parts of the world. The intestine of freshly killed flies should be teased out in normal saline solution. Permanent preparations may be made by fixing and staining smears by the Schaudinn iron-hæmatoxylin method or by the Giemsa method.

About 40 per cent of several dozen flies examined by us were found to be infected with *Herpetomonas.* Plate 5, fig. 56, shows some of the different types present.

Mosquitoes.—We are indebted to Dr. C. Manalang for specimens of anopheles mosquitoes containing coccidia (Plate 1, fig. 18). According to Manalang (1929) no records of coccidial infections of mosquitoes had been published previous to his account. Manalang found oöcysts in from 1 to 2 per cent of all the common species of adult anopheles from the Novaliches Water Project and the San Francisco malaria control areas near Manila, both in the spring of 1928 and of 1929. These

included *Anopheles minimus,* a carrier of human malaria, *A. vagus,* and *A. tessellatus.* He also noted oöcysts in the larva of *A. tessellatus.* Either two species or two stages in the life cycle of one species were observed. Certain oöcysts were brownish yellow and measured from 66 microns by 37 microns to 31 microns by 25 microns; the average was 44.8 microns by 29 microns. Others were colorless and slightly smaller, ranging from 58 microns by 31 microns to 25 microns by 24 microns; the average was 37.8 microns by 26.7 microns. Adults contained oöcysts almost everywhere throughout the body except the midgut, brain, and eggs. In the parasitized larva the oöcysts were distributed to all parts of the body. No developmental stages within the oöcysts were observed.

Cockroaches.—Cockroaches are common household insects, and their association with man makes them of special interest to protozoölogists because of the possibility that they may serve as vectors of human Protozoa. It does not seem probable that the Protozoa ordinarily present in the cockroach belong to the same species as those living in man, but material containing human Protozoa is no doubt often ingested by cockroaches, and if these Protozoa are able to pass through the digestive tract of the insect in a viable condition they might be deposited in the food or drink of man and thus bring about infection. Amœbæ and ciliates belonging to the same genera as those living in man commonly occur in cockroaches; these are *Endamœba* and *Balantidium.* It seems certain, however, that the species are different and that cross-infection rarely if ever takes place. Attempts to infect cockroaches with the trophozoites of certain human Protozoa have shown that these are unable to pass through the digestive tract without being destroyed (Hegner, 1928). Whether cysts can withstand the conditions in the stomach and intestine of the insects is still to be determined. The intestinal Protozoa that may usually be found in cockroaches are *Endamœba blattae,* a very large species; a smaller species of *Endamœba, E. thomsoni;* an *Endolimax, E. blattae;* two or more species of ciliates, *Balantidium blattarum* and *Nyctotherus ovalis;* several species of flagellates, including *Hexamita periplanetae, Lophomonas blattarum,* and *L. striata;* and *Retortomonas orthopterorum.* Besides these, half a dozen species of gregarines have been described from these insects.

Three species of cockroaches were examined by us, all captured in Manila, as follows: *Periplaneta americana,* six speci-

mens; *Nauphoeta cinerea,* three; and *Rhyporobia maderae,* two. Every specimen examined contained intestinal Protozoa but the species of cockroaches differed widely with respect to the species of Protozoa living in them, even when the hosts were collected from the same market. It is obviously not sufficient to state that a certain species of Protozoon occurs in the cockroach, but the species of cockroach should always be specified. The great difference in the intestinal fauna of different species of cockroaches living in the same environment suggests experimental studies on host-parasite specificity. Cockroaches can easily be freed from their intestinal Protozoa by the oxygenation method (Cleveland, 1925), and can then be fed easily on material from other species of cockroaches (Hegner, 1928).

The species present in the six specimens of *Periplaneta americana* that we examined were as follows: *Nyctotherus ovalis* (fig. 48), abundant in five specimens; *Endamœba thomsoni* (fig. 51), a few to many in five specimens; *Hexamita periplanetae,* present in all specimens; *Retortomonas orthopterorum,* present in three specimens; *Endamœba blattae* (Fig. 49), many in one specimen; *Lophomonas striata* (Fig. 54), and *L. blattarum* (Fig. 55) present in one specimen; gregarines, many in one specimen. These Protozoa were examined in the living condition only, no stained preparations being prepared. It is, therefore, impossible to state from a detailed study whether they differed specifically from the list as given above.

The three specimens of *Nauphoeta cinerea* examined were particularly characterized by the large number of gregarines present. At least three species of these could be distinguished. Besides gregarines, there were many amœbæ belonging apparently to several species, but no *Endamœba blattae,* and two or three species of very small flagellates.

Rhyporobia maderae, of which two specimens were examined, also contained many gregarines of several species. Flagellates, probably of the genera *Hexamita* and *Retortomonas,* were present in large numbers.

Endamœba blattae (Plate 4, fig. 49) is a very large amœba and hence of great value for classroom study. It is the type species of the genus *Endamœba;* it was described and named by Leidy in 1879. The nucleus is conspicuous in the living animal and has a heavy membrane. The cytoplasm is grayish, and no clear ectoplasm is visible. As the organism moves along, dark lines appear in the cytoplasm parallel to the direction of

locomotion. This species occurred in large numbers in the rectum of most of the specimens of the cockroach *Periplaneta americana* collected at the Divisoria Market, in Manila, but was absent from all of those obtained from one of the hospitals. It is advisable, therefore, when looking for *E. blattae*, to examine cockroaches from several different localities. The life cycle of *E. blattae* has been described in detail by Mercier (1910) but needs to be confirmed.

The following species of gregarines are listed by Watson (1916) from cockroaches: *Gregarina blattarum* from *Periplaneta orientalis, P. americana,* and *Blatella germanica; G. serpentula* from *Periplaneta orientalis;* and *Gamocystis tenax* from *Blatella lapponica.*

The criteria of use in distinguishing species of gregarines are "size, both medium and average; ratio of length of protomerite to total length; ratio of width of protomerite to width of deutomerite; general shape of the body; shape of the protomerite; shape of the deutomerite; character of the interlocking device; size and shape of the nucleus; color and character of the protoplasm; and size and shape of the cysts and their method of dehiscence." (Watson, 1916, p. 42.) Several types of gregarines found by us are probably undescribed species and would well repay detailed study.

PROTOZOA OF SNAILS

Certain snails of the genus *Ampullaria* that are abundant in the fresh waters of the Philippine Islands are infected with *Balantidium haughwouti* de Leon (1919). A snail, *Melania blatta* Lea, that we collected in considerable numbers at San Francisco del Monte, was infected with balantidia, which may be *B. haughwouti.*

PROTOZOA OF PLANTS

The interesting fact that parasitic Protozoa may live in plants as well as in animals was demonstrated by Lafont in 1909, who described a flagellate from the latex of a plant, *Euphorbia pilulifera,* on Mauritius. Since then flagellates have been reported from latex-bearing plants belonging to several families and from Europe, Asia, Africa, and North and South America. None have heretofore been reported, so far as we know, from the Philippine Islands. The generic name *Phytomonas,* proposed by Donovan in 1909, has been adopted by several protozoölogists for these flagellates, largely because of their peculiar habitat.

Holmes (1925) has probably furnished the best life-history studies of any member of the genus. He has described the species *P. elmassiani* from milkweed plants, *Asclepias syriaca,* in the eastern United States and has found these flagellates in what appears to be undoubtedly their intermediate host, a bug, *Oncopeltus fasciatus,* which feeds on milkweed plants. Within this plant, *P. elmassiani* is confined to the latex system and is intracellular but not intracytoplasmic. Certain latex cells may be infected and others not, within a single plant. The flagellates occur only in the salivary glands of the bug where they are localized in the dorsal and anterior lobes but do not occur in the posterior lobe of the gland.

Phytomonas seems to be pathogenic to certain euphorbias but does not seem to injure milkweeds. The true host-parasite relations of the genus are, however, still to be determined. Many species of Euphorbiaceæ and other latex-bearing plants occur in the Philippines. These would well repay careful examination. Suggestions regarding problems have been published recently by Holmes (see Hegner and Andrews, 1930).

We have examined the latex of a large number of species of plants growing in and around Manila and belonging to nine different families as listed below. These plants were obtained through the kindness of Dr. E. Quisumbing, of the Bureau of Science, Manila. As a rule, only one plant of each species was examined. The only species found to be infected was *Euphorbia hirta.* About 60 per cent of the plants contained flagellates, many of which remained alive in the latex within the plants for at least twenty-four hours after being brought into the laboratory. Several types of flagellates are shown on Plate 5, fig. 57.

TABLE 3.—*Plants examined for flagellates.*

Anacardiaceæ.
- *Mangifera indica* Linn.

Apocynaceæ.
- *Allamanda hendersonii* Bull.
- *Allamanda cathartica* Linn.
- *Plumiera acuminata* Ait.
- *Tabernaemontana divaricata* (Linn.) R. Br.
- *Tabernaemontana pandacaqui* Poir.
- *Thevetia peruviana* (Pers.) Merr.

Asclepiadaceæ.
- *Calotropis gigantea* (Linn.) Dryand.
- *Dischidia ruscifolia* Decne.
- *Dischidia vidalii* Becc.

Campanulaceæ.
- *Isotoma longiflora* (Mill.) Presl.

Caricaceæ.
- *Carica papaya* Linn.

Convolvulaceæ.
- *Ipomoea batatas* (Linn.) Poir.

Convolvulaceæ—Continued.
Ipomoea cairica (Linn.) Sweet.
Ipomoea fistulosa Mart.
Ipomoea reptans (Linn.) Poir.

Euphorbiaceæ.
Euphorbia heterophylla Linn.
Euphorbia hirta Linn.
Euphorbia pulcherrima Willd.
Euphorbia splendens Boj.
Euphorbia tirucalli Linn.
Euphorbia trigona Haw.
Jatropha curcas Linn.
Manihot utilissima Pohl.
Melanolepis multiglandulosa (Reinw.) Reichb. f. and Zoll.

Euphorbiaceæ—Continued.
Pedilanthus tithymaloides Poir.
Phyllanthus reticulatus Poir.

Moraceæ.
Artocarpus communis Forst.
Artocarpus cumingiana Trec.
Artocarpus integra (Thunb.) Merr.
Ficus elastica Roxb.
Ficus hauili Blanco.
Ficus minahassae (Teysm. and De Vr.) Miq.
Ficus nota (Blanco) Merr.
Ficus religiosa Linn.
Morus alba Linn.

Sapotaceæ.
Chrysophyllum cainito Linn.

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ILLUSTRATIONS

PLATE 1. COCCIDIAL OÖCYSTS FROM PHILIPPINE ANIMALS

FIGS. 1 to 3. Three stages in the development of oöcysts of a species of *Eimeria* from the rabbit.

4 to 6. Stages in the development of the oöcyst of another species of *Eimeria* from the rabbit.

7 to 9. Stages in the development of the oöcyst of a third species of *Eimeria* from the rabbit.

10 and 11. Two stages in the development of the oöcyst of an *Eimeria* from a bat.

12 and 13. Two stages in the development of an *Isospora* from the ruddy kingfisher, *Halcyon coromandus*.

FIG. 14. An oöcyst of *Isospora* from the crested myna, *Æthiopsar cristatellus*.

15. An oöcyst of *Isospora* from the pied lalage, *Lalage niger*.

FIGS. 16 and 17. Two stages in the development of an *Eimeria* from the python.

FIG. 18. An oöcyst from a larval stage of a mosquito, *Anopheles tessellatus*.

All figures of Plate 1 were drawn with a camera lucida from living specimens; they are all magnified 1000 diameters except fig. 18 which is magnified 250 diameters.

PLATE 2. HAEMOPROTEUS FROM PHILIPPINE BIRDS

FIGS. 19 to 25. *Haemoproteus* in the red-blood cells of the broad-billed roller, *Eurystomus orientalis*. *19*, One small parasite; *20*, two larger parasites in one red cell; *21*, two parasites almost fully grown in one red cell; *22*, a fully grown and a young parasite in one red cell; *23*, two fully grown parasites in one red cell; *24*, three large parasites in one red cell; *25*, a parasite free in the blood stream.

FIG. 26. *Haemoproteus* in a red-blood cell of the Philippine sparrow hawk, *Accipiter manillensis*.

FIGS. 27 to 31. *Haemoproteus* in the red-blood cells of the Java coucal, *Centropus javanicus*. *27*, Uninfected red cell; *28*, parasite free in the blood stream; *29* to *31*, three fully grown parasites within red cells.

FIGS. 32 to 34. *Haemoproteus* in the red-blood cells of the Philippine oriole, *Oriolus acrorhynchus*.

FIG. 35. *Haemoproteus* in a red-blood cell of Lindsay's kingfisher, *Halcyon lindsayi*.

All figures of Plate 2 were drawn with a camera lucida from specimens stained with Giemsa; they are all magnified 2,300 diameters.

PLATE 3. PROTOZOAN PARASITES OF PHILIPPINE ANIMALS

FIG. 36. *Balantidium* from a frog, *Rana vittigera.*
37. *Balantidium* from *Rana vittigera,* in division.
38. An *Endolimax* amœba from *Rana vittigera.*

FIGS. 39 to 41. *Plasmodium* from the Philippine bulbul, *Iole gularis. 39* and *40,* Parasites free in the blood stream; *41,* An uninfected red cell.

FIG. 42. A segmenting specimen of *Plasmodium* in a red-blood cell of the large-nosed shrike, *Cephalophoneus nasutus.*

FIGS. 43 to 46. *Plasmodium* in the red-blood cells of the gray-head shrike, *Otomela lucionensis. 43,* A parasite free in the blood stream; *44,* an uninfected red cell; *45* and *46,* fully grown parasites within red-blood cells.

FIG. 47. *Balantidium* from a frog, *Kaloula picta.*

All figures of Plate 3 were drawn with a camera lucida; figs. 36 to 38 and 47 from living specimens and the rest from specimens stained with Giemsa. Magnifications are as follows: Figs. 36 and 38, 1000 diameters; fig. 37, 250 diameters; figs. 39 to 46, 2,300 diameters; fig. 47, 500 diameters.

PLATE 4. PROTOZOAN PARASITES OF PHILIPPINE ANIMALS

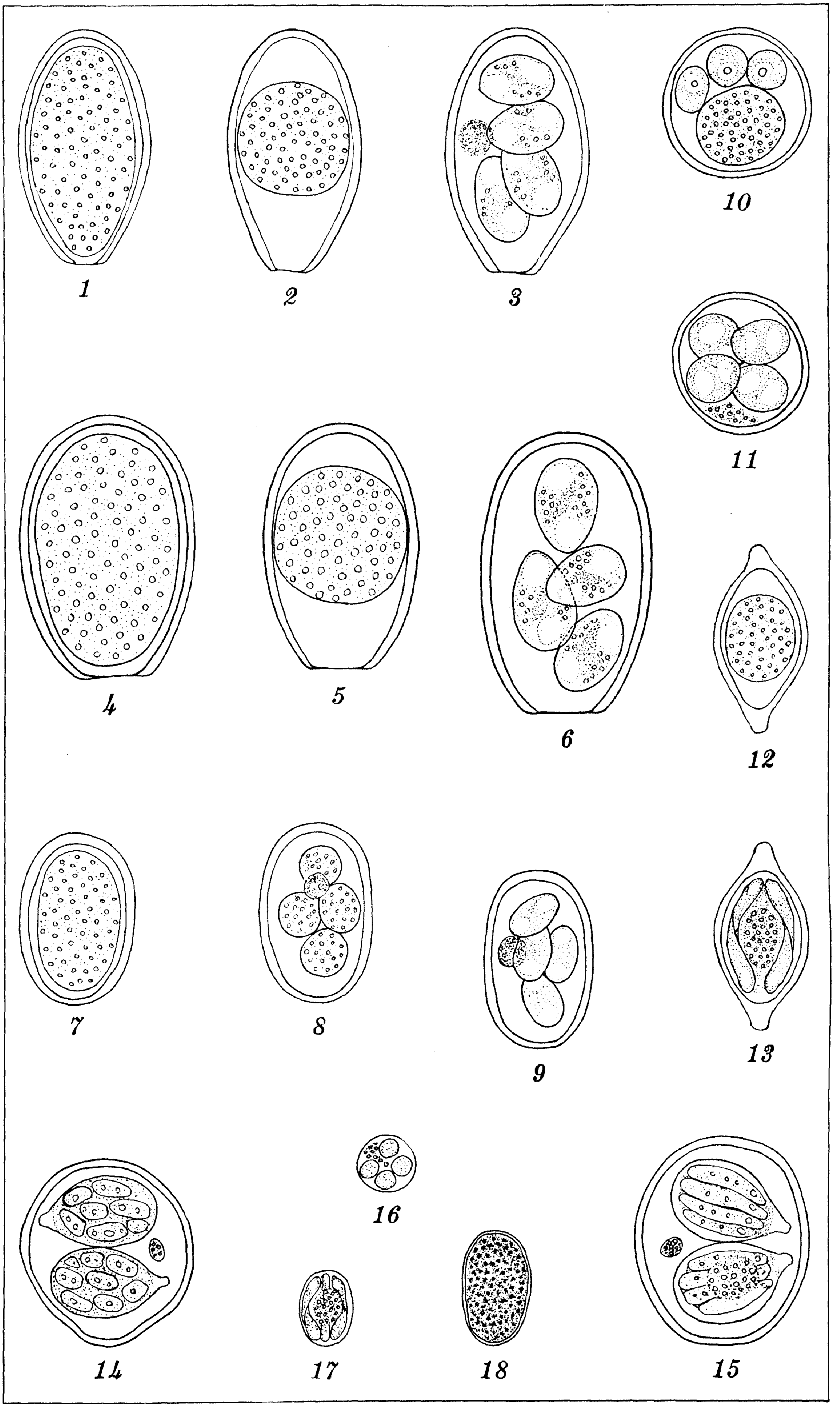
FIG. 48. *Nyctotherus* from a cockroach, *Periplaneta americana.*
49. *Endamœba blattae* from a cockroach, *Periplaneta americana.*
50. *Endamœba* from the domestic fowl.
51. An amœba from a cockroach, *Periplaneta americana.*
52. *Endolimax* from the domestic fowl.
53. An amœba from a house rat.
54. *Lophomonas striata* from a cockroach, *Periplaneta americana.*
55. *Lophomonas blattarum* from a cockroach, *Periplaneta americana.*

All figures of Plate 4 were drawn with a camera lucida from living specimens. Magnifications are as follows: Fig. 48, 780 diameters; fig. 49, 500 diameters; figs. 50 and 52, 2000 diameters; figs. 51, 53, 54 and 55, 1000 diameters.

PLATE 5. FLAGELLATE PROTOZOAN PARASITES FROM HOUSEFLY AND PLANTS

FIG. 56. *Herpetomonas muscae-domesticae* from the intestine of a house-fly. Typical specimen at the right; dividing stages at the left.
57. *Phytomonas* from a plant, *Euphorbia hirta.* Typical specimen at the left; dividing stages at the right.

All figures of Plate 5 were drawn with a camera lucida, at a magnification of 2300 diameters, from specimens stained with Giemsa.



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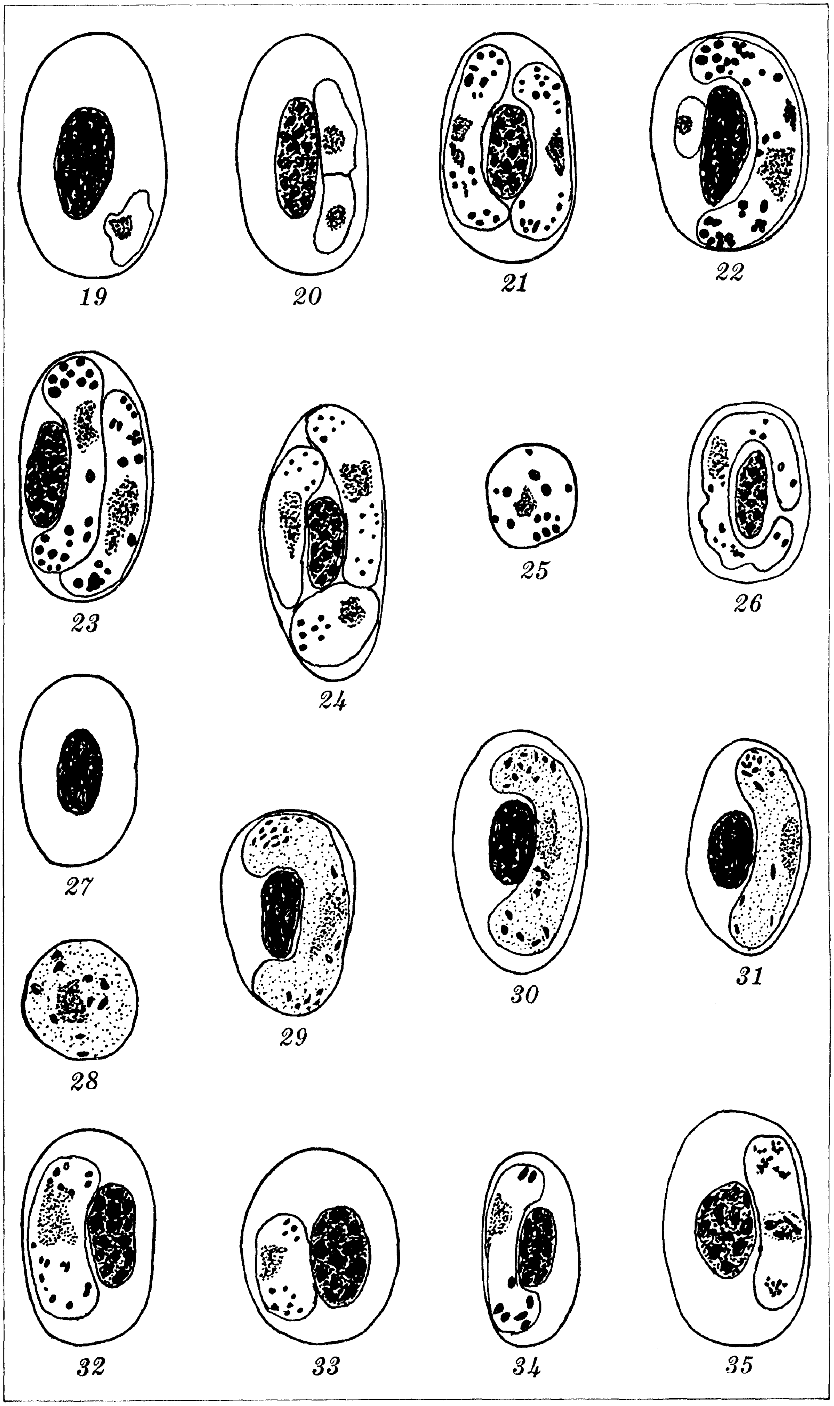


PLATE 2.

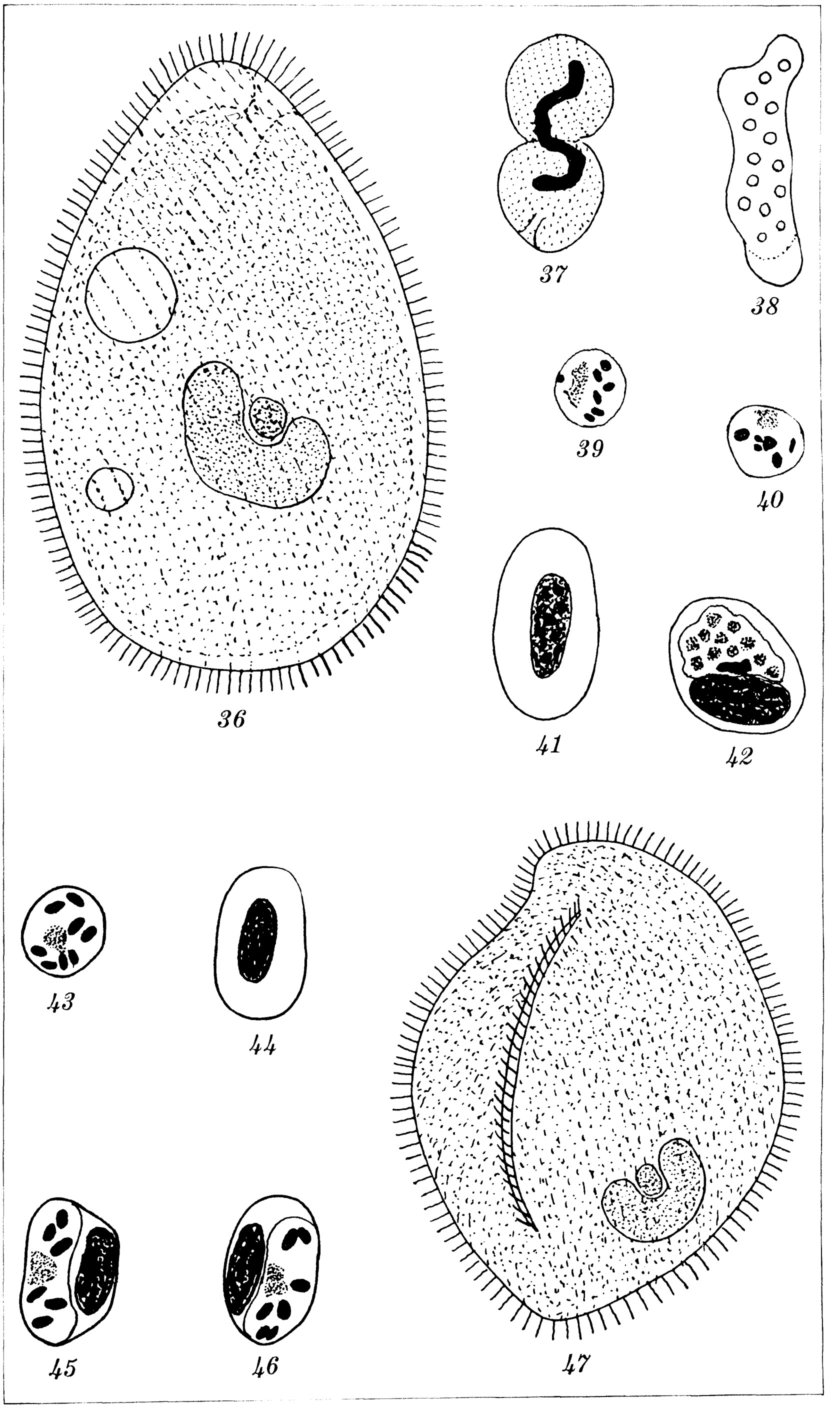
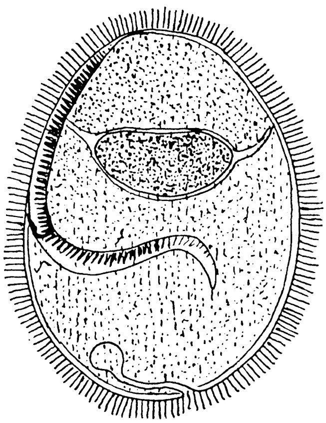


PLATE 3.



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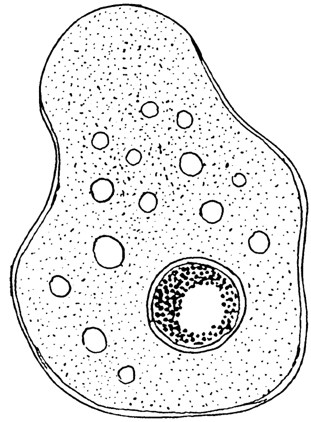

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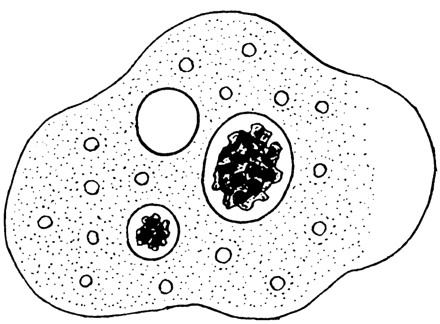

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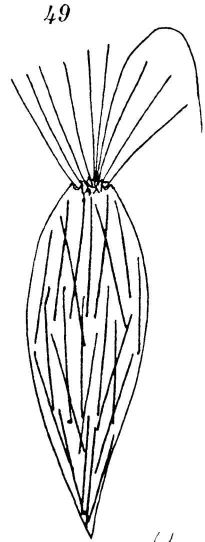

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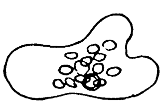
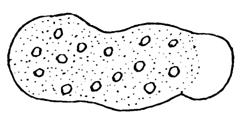
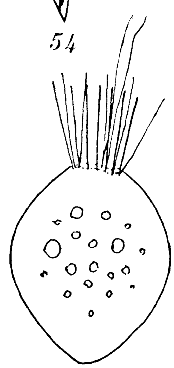


51



52



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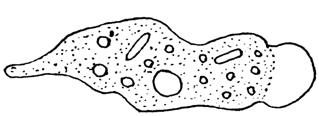
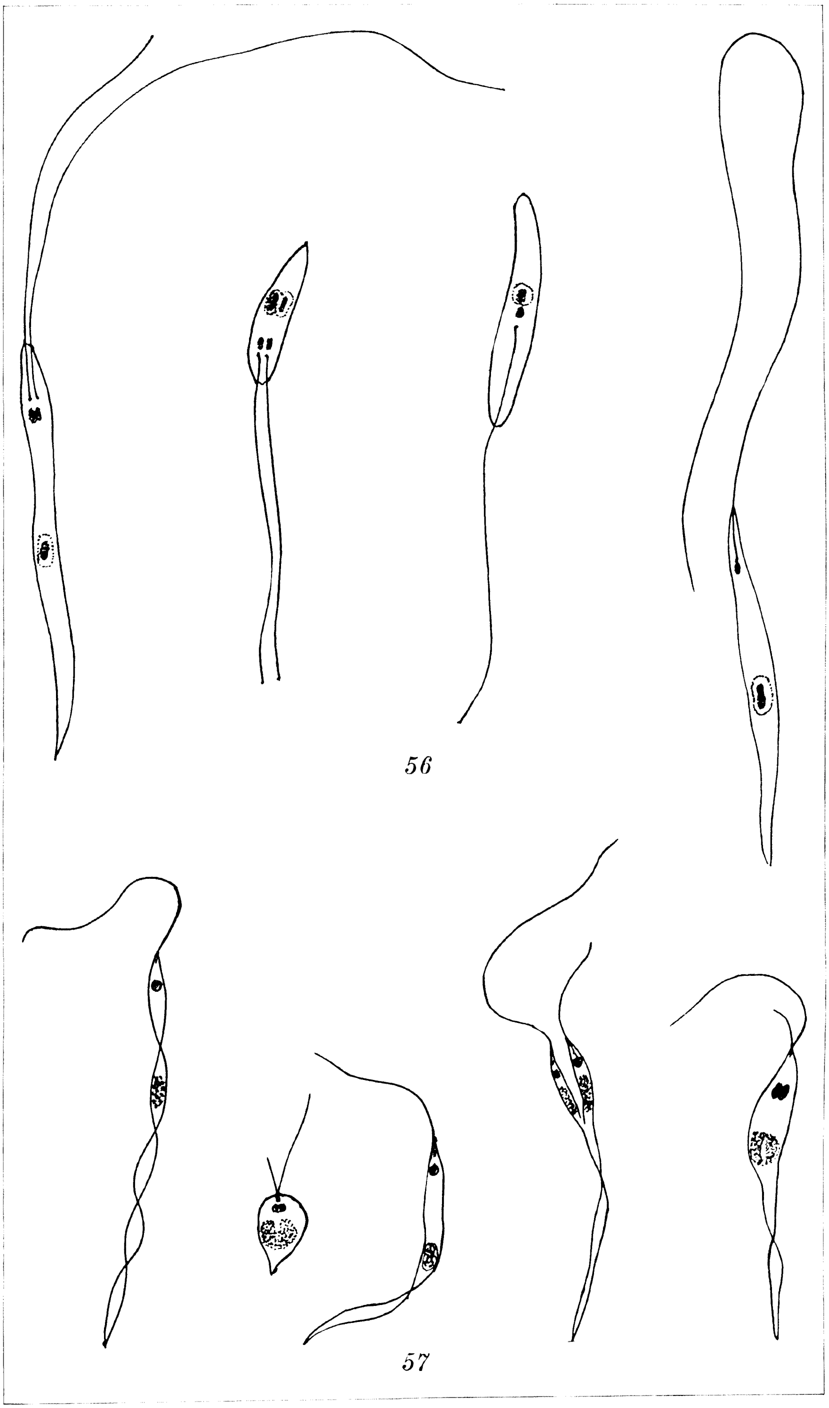


53

PLATE 4.



56

57

PLATE 5.

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CONTENTS

Page.

ROXAS, MANUEL L., and MANUEL VILLANO. Studies on the development of the sugar-cane plant in the Philippines. Root and shoot development of M-1900 367

MUNDO, SALVADOR DEL. The occlusion of lead and copper in nonferrous alloys by metastannic and metantimonic acids 403

SANTOS, IRENE DE, and AUGUSTUS P. WEST. Naphthol esters of chaulmoogric acid and chaulmoogryl naphthylamines 409

HARRIS, HALBERT M. Notes on Philippine Nabidæ, with a catalogue of the species of Gorpis (Hemiptera) 415

MIYAO, ISAO. An inquiry into the so-called latent infection in yaws-vaccinated monkeys as a possible result of the test for immunity by intradermal inoculation with living yaws material 425

MIYAO, ISAO. Immunologic relation between three Philippine strains of yaws 429

MIYAO, ISAO. Is framboesia tropica a nosologic entity? 433

HEGNER, ROBERT, and H. J. CHU. A survey of Protozoa parasitic in plants and animals of the Philippine Islands 451

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# THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 43 DECEMBER, 1930 NO. 4

PEARL FISHERIES OF SULU

By FLORENCIO TALAVERA
Of the Division of Fisheries, Bureau of Science, Manila

SEVEN PLATES

INTRODUCTION

January 3, 1930, I left Manila for Sulu for the purpose of investigating the present conditions surrounding the pearling industry of the Sulu Archipelago. One month was spent in the study, and my investigations were conducted chiefly in the vicinities of Zamboanga, Basilan, Jolo, Siasi, Bongao, and Sitanki. The most important men who were familiar or intimately connected with the industry, such persons as Government officials, Chinese, Japanese, and Moro pearl merchants, divers, and fishermen, of the places visited, were consulted or interviewed. The information obtained from one locality was checked up in another. In the following paragraphs is embodied all that I could learn, through information and personal observation, about the present situation of the pearl fishery of the Sulu Archipelago.

The Sulu Archipelago is an extensive natural pearling ground. It is located between 4° and 7° north latitude and is bounded by the Sulu Sea on the north and the Celebes Sea on the south and east. The archipelago extends for its entire length of 137 miles in a southwesterly direction from Basilan to Borneo. It consists of two main groups of islands—the Jolo group and the Tawitawi group—which are again divided into thirteen small groups with about one hundred thirty fairly large islands and some one hundred seventy islets and reefs. The islands and

islets are either volcanic or coralline. Between these islands the currents are swift. The water is uniformly warm practically throughout the year, and clear, except in shallow soundings where, during strong wind, the waves stir up the bottom which consists of sand or gravel made up of broken coral and shells, or fine ooze. Eel grass and other marine plants thrive abundantly in the shallow places. In the deep water there are "pockets," or pearl beds, that serve as natural nurseries from which millions of eggs are produced and scattered by the currents; they settle on the shallow banks to develop. The existence of these pockets, which keep a constant supply of pearl oysters growing toward maturity, is a strong biological explanation of the fact that the pearl beds, especially in the shallow-water grounds, have not been depleted after many years of fishing. Naturally, the Sulu Archipelago is so favored as to possess all the requisites for the favorable growth of pearl oysters, thus making the whole region one great pearling bank, the largest and most prolific in the Philippines.

PEARL BEDS IN SULU

There are nine pearl beds in the Sulu Archipelago; namely, (*a*) the Basilan, (*b*) the Pilas, (*c*) the Samales, (*d*) the Pangutarang, (*e*) the Jolo, (*f*) the Laparan, (*g*) the Tapul, (*h*) the Tawitawi, (*i*) the Sibutu. The first four in the list lie above and the last four below the sixth degree of north latitude; the area of the Jolo pearl beds is cut into two sections by the dividing line which coincidentally passes through the town of Jolo.

Seale studied these beds, and his findings were published in 1916.[1] As far as I could learn, during my survey covering a little over a month, the general conditions surrounding these grounds are just as good as in 1916; the shallow-water patches or banks, which are regularly worked by the Moro naked divers, yield an ample return of shells; the grounds on the whole are just as prolific as ever, judging from the amounts of shells obtained as shown in the records at the custom houses in Zamboanga and Jolo.

It is generally believed, by those who know by actual observation, that the Tawitawi beds are the richest grounds in the Sulu Archipelago. The numerous islets, reefs, and shoals included in this group, with the rich vegetation growing on the

[1] Philip. Journ. Sci. § D 11 (1916) 245.

bottom which consists mainly of sand, coral, and broken shells, are favorable factors in the fertility of the grounds. The water is shallow, and the currents between the islands and reefs are swift.

PRESENT CONDITION OF PEARL BEDS

The Basilan pearl beds.—At the time of my inspection there were two pearling sailboats, the *Togo* and the *Alice,* equipped with handpumps, operating on the beds near Malamaui Island. These vessels, now managed by Mr. Maehara, a Japanese merchant of Zamboanga, are manned with Moro crews. The divers are Japanese. A total of five hundred shells was secured by the two boats in about fourteen days of actual work. No pearls were found in these shells. According to Mr. Maehara, who has been in the pearling business for over fifteen years, the Basilan pearl beds yield a fair return of shells and their natural supply seems inexhaustible. The shells from this area are excellent and produce pearls of good quality. The Basilan pearl beds are in no immediate danger of exhaustion. The known grounds are fairly extensive, and there is no doubt that there are banks around this region that have not yet been discovered.

The Pilas pearl beds.—Included in this group are several small islands and many islets with their shoals and reefs. Shells occur here in fairly large numbers, but the yield during the northeast monsoon is usually irregular and uncertain due to strong wind and sand disturbance, which greatly handicap operation. The beds can be worked profitably only during the southwest monsoon. Mr. Kawaguchi, manager of the motor pearler *Sumiyoshi,* stated that during the northeast monsoon the shells are covered by the shifting sand and as a result many, both young and adult, die; but there is always a sufficient number of young and old oysters to be found when the beds are worked the following season. This observation finds explanation in the fact that some shells survive the adverse period and continue growing and reproducing, and that the grounds are supplied with the young from adjacent beds.

The Samales pearl beds.—The known grounds on these beds are rich. Divers and sailors as well as boat owners reported that the pearling banks, particularly the shallow-water areas around the islands north and west of Tonquil Island, are prolific. Shells occur abundantly in the deep water. Pearls of excellent quality have been secured from this region. The beds are in good condition.

The Pangutarang pearl beds.—These beds are considered one of the richest pearling grounds in Sulu. The banks east of Basbas Island are particularly productive. January 30 last, the *Kotohira* brought to Jolo five hundred twenty-nine shells fished in the vicinity of Basbas, Cumilan, and Usada Islands. The Moro diver informed me that the north wind had been too strong for the boat to operate around the adjacent beds, which are known to be rich in shells. It was said that the *Kotohira* on this trip obtained one pearl valued at 800 pesos; I went to see the Chinese manager of the vessel about this but he was noncommittal. It is this secretive attitude of the pearl merchants that makes any estimate of the income from the sales of pearls taken in Sulu waters rather uncertain and unreliable. The Pangutarang beds are in no danger of exhaustion.

The Jolo pearl beds.—The productive sections of these beds are the shoals and channels between the islands north of Jolo and the channel in front of the town of Jolo. The Moros for over a hundred years have been diving for pearls in this region, and there has been no apparent diminution in the yield of pearl shells. The beds are just as rich as ever. However, it is believed that the conditions in this locality are not favorable for the production of pearls. Rarely, if ever, are pearls found in the shells from the Jolo beds.

January 18 I was a guest on board the pearler *Aki.* This is a motor boat equipped with a modern diving outfit. Hadji Gulamu Rasul and Mr. Kashiwagi, president of the Sulu Pearling Co., Inc., arranged the trip. The boat worked in three different places in the channel in front of the town of Jolo. Two Japanese divers made the three dives of twenty-five minutes each in depths of from 22 to 25 fathoms. Some of the shells secured were already old, broken, or encrusted. There were six good shells of large size. The divers informed me that they found a goodly number of young shells of various sizes on the bottom, which is of fine ooze.

January 31 last, I boarded the *Sumiyoshi,* another motor yacht with motor pump, for the purpose of examining the beds in the vicinity of Marungas Island. The weather was fair, but the captain, a Visayan-Moro, and the diver, a Capiceño, and the Japanese supercargo, all stated that it would be inexpedient to go farther north; accordingly, the operation was confined to the southern waters of Marungas at a depth of 24 fathoms. Two dives of thirty minutes each were made. Twelve shells were ob-

tained, six of which were good and large, four large but broken and encrusted, and two undersized. The good shells were opened, but no pearls were found. Moro naked divers on vintas were working around Taglibi, Mainbung, and Parang. It appears that the Jolo beds are in no danger of depletion.

The Laparan pearl beds.—The many small islands, islets, and reefs that comprise these beds, lying well northward in the Sulu Sea, have favorable pearl-shell patches, and it has been reported that the natural supply could withstand without damage the operation of the present pearling fleet. A rich area has been recently discovered near Cap Island. In certain deep places pearl oysters are plentiful, but they are generally grouped too closely and the majority of them are old and worm eaten, perforated by boring sponges, or damaged by other natural enemies. Working these beds regularly would remedy this condition, and would in all probability increase the yield and improve the grade of shells. Some excellent pearls have been obtained from these grounds.

The Tapul pearl beds.—The pearl-shell patches of this area are more or less localized in the channels between Siasi and Lugus and Tapul. The Japanese and Moro divers who have worked on these beds for years informed me that there are plenty of shells here, but the water is deep and the current is usually so swift that operation is difficult. Excellent pearls have been secured from this region. In the shallow water around these islands Moro naked divers obtain plenty of shells, which are sold to the Chinese in Siasi.

The Tawitawi pearl beds.—These beds comprise the most prolific pearling grounds in the Sulu Archipelago and, as far as known, in the entire Philippines. Rich pearl-shell banks are located in the shallow water around Bubuan, Magpeos, Tagao, and South Ubian. In most of these places the water is too shallow for a pearling boat to operate. It is around this region that hundreds of Moro naked divers, the majority of whom are natives of South Ubian, find pleasure and profit in an occupation for which they have been trained. In the vicinity of Bongao good shells are found, but they generally occur singly. The deep sea around Cacataan Island abounds with shells of excellent grade, and pearls of the first water have been obtained from them. It is interesting to note that the majority of the shells taken from these beds have blisters, which invariably contain good pearls, especially when formed in the thicker portion of the

shell. The Tawitawi pearl beds are in good condition and could sustain the operation of a large pearling fleet without damage to the fisheries, which are constantly supplied by the local breeds as well as by those from the adjacent grounds.

The Sibutu pearl beds.—Nothing very definite is known about the pearl-shell patches in this area. Although the region as a whole has not been intelligently examined, apparently, it is rich in pearl shells, since the physical conditions surrounding the islands, reefs, and shoals west of Sibutu Passage are conducive to the growth of pearl oysters. According to Mr. Machlan, postmaster, custom collector, and deputy governor at Sitankai, the Moros occasionally bring into town some pearl shells secured from the shoals of Bulubulu, Tumindao, and Wooded Islands, but their harvest has been very small. In all probability in the deep water considerable numbers of shells could be found, but whether the Sibutu pearl beds are sufficiently extensive so that a large pearling fleet could find profitable work is doubtful. However, it was reported by the pearlers who had worked around the islands west of Alice Channel that pearl shells are plentiful there. This strengthens the probability that the Sibutu pearl beds are as rich as those located near the mouth of Darvel Bay, for the regions are contiguous and represent the connecting links between the Sulu Archipelago and Borneo.

REMARKS

In brief, as far as I could learn, these nine pearl beds are in no immediate danger of depletion. It is possible, however, that some rich pearl patches localized around certain islands may suffer from overfishing, for there are several such grounds that, because they are sheltered practically at all seasons, permit continuous operation of the pearlers and naked divers. However, this situation will eventually solve itself, because as soon as fishing on these grounds becomes unprofitable, the pearlers will naturally seek other places, leaving the beds to recuperate. The Sulu pearl banks usually recover in a comparatively short time. It has been observed that oyster shells in Sulu waters grow rather rapidly, there being no cold spells as in Japan and Australia to retard their growth activity. The Philippine pearl oyster (*Margaritifera maxima*) is sexually mature in two years and attains the "present legal size;" that is, 14 centimeters nacre measurement in about three or four years. As a matter of fact, divers do not and cannot take out all the available fishable (legal) oysters on a bank at a fishery. Thus, even under such

seemingly adverse circumstances attributed to "probable overfishing," the danger is not of a serious and permanent nature.

The majority of the rich grounds are either exposed or sheltered during each change of the two prevailing winds in the Philippines. Pearling in Sulu is, therefore, controlled by the northeast and southwest monsoons. This condition is in itself a great natural provision that automatically regulates the activities of the pearlers.

In view of the above facts, it appears that any division of these nine beds into two sections is unnecessary. However, it may be expedient, under serious circumstances, to segregate the Tawitawi or any rich area into districts or zones, each of which is to be treated separately; that is, provisions for closed seasons should be drawn up for each district; but this arrangement would entail large expense and necessitate strict enforcement in order to be effective. I doubt if the revenue received from the industry would defray the Government expenses incurred in patrolling the zones in question. Herein lies the failure of such regulation; and regulation that cannot be strictly enforced is worse than useless, since it is human nature to attempt to evade restrictions that can be easily eluded. Poaching in the restricted zone or zones cannot be prevented, unless there is adequate Government patrol.

January 25, while returning from Sitanki and Bongao on board the *Doña Carmen,* I sighted four pearling boats operating off Cacataan Island; and the next day three yachts were noticed working in the vicinity of Siasi, Lapac, and Lugus Islands. These places are not open for pearl fishing until after January 1, 1932, according to Department Order No. 7. The violation was brought to the attention of the customs collector in Jolo. The boat owners pleaded guilty. Business necessity forced them to violate the restriction. The boats could not work on the northern beds, on account of the strong northeast monsoon; and in the shallow-water grounds around most of the islands, the waves were rough and made the water muddy or turbid, preventing the divers from seeing the shells. During November, December, and January the pearlers were practically idle. It is obvious, therefore, that for economic reasons the boats worked wherever and whenever possible. I believe that there have been other offenses against Department Order No. 7 since January 1, 1929. The closed area is fairly large, with numerous islands and islets where clandestine pearling could be carried on with impunity, due to the inadequate means of enforcement.

The nine pearl beds in the Sulu Archipelago could be opened. The region from Basilan to Alice Channel is sufficiently extensive to sustain the operation of a large pearling fleet and the activities of the naked divers, who are confined entirely to the shallow-water grounds which seem inexhaustible. In the deeper waters there are undiscovered reserve pearl banks. The natural supply is maintained by the regulatory influence of the monsoons, which brings about rotation in the working of the pearl beds. The Sulu pearl banks are in no immediate danger of exhaustion.

The introduction of powered boats with motor-driven pumps would be dangerous to the fisheries, but, at present, of the twenty-four vessels in the pearling fleet engaged in Sulu waters only five are of this type. It is doubtful that this number will increase rapidly to such an extent as to threaten the stability of the fisheries, since a yacht so equipped costs from 8,000 to 10,000 pesos and its running expenses are comparatively high.

EXPENSES FOR OPERATING PEARLERS

The following statements were furnished me by Mr. Kashiwagi, president of the Sulu Pearling Co., Inc., and Mr. Schuck, owner of the *Rene*.

Expenses for operating a motor yacht with motor pump.

[For October, 1929.]

	Pesos.
Tender wage	45.00
Sailors wage	87.00
Oto wage (spare sailor)	7.00
Engineer wage	35.00
Shell wage paid to diver	180.18
Diver wage, monthly bonus	30.00
Market expenses	60.00
Rice, 4 sacks	43.00
Gin and tobacco	7.50
Medicine for crew	2.75
Dress, 1 pc. (diving)	140.00
Patch cloth for patching dress	15.00
Diver stocking, 1 pair	8.50
Miso and soy	4.00
Life line, $1\frac{3}{4}$-inch abacá rope	18.70
Lamp	2.10
Kerosene oil for machine	114.30
Gasoline oil and motor oil	18.00
Expenses to machine repairing	10.80
Bucket and rice pot	9.40
Total	838.23

Expenses for operating a motor yatch with motor pump—Continued.

[For November, 1929.]

	Pesos.
Market expenses	56.00
Rice, 4 sacks	43.00
Miso and soy	3.70
Gin and tobacco	7.80
Kerosene oil	108.00
Gasoline oil and motor oil	20.00
Tender wage	45.00
Sailors wage, 5 men	86.00
Oto wage	7.00
Engineer wage	35.00
Diver salary	30.00
Boarding fee at spring time	20.00
Medicine	2.00
Diving hose, 1 length, 9 fathoms (54 feet)	65.00
Marine rope	3.40
Munt metal and copper tuck	12.50
Canvas and twine	18.60
Patching cloth to repair dress of diver	10.00
Shell bonus paid to diver	79.00
Total	642.00

[For December, 1929.]

	Pesos.
Internal-revenue tax	36.87
Kerosene oil	113.00
Gasoline and motor oil	20.00
Rice, 4 sacks	44.00
Miso and soy	4.50
Medicine to crew	2.00
Gin and tobacco	7.50
Rope, 4-inch abacá, half coil	28.50
Tender wage	45.00
Sailors wage, 5 men	86.00
Oto wage	7.00
Engineer wage	35.00
Diver bonus for the month	30.00
Diver boarding expenses	20.00
Christmas bonus to sailors	35.00
Christmas bonus to divers	45.00
Market expenses, fish and vegetables	58.00
Fishing line	1.50
Leather and marine rope	3.70
Paint and painting oil	8.90
Cooking wear; dish, spoons, pots, etc.	4.80
Shell wage to diver	156.20
Total	792.48

Expenses for running a sailing boat with hand pump.

[For October, 1929.]

	Pesos.
Market expenses, fish and vegetables, etc.	58.00
Miso and soy	3.50
Kerosene oil	1.50
Pump oil, olive oil, pure	2.00
Gin and tobacco	6.00
Medicine for crew	2.70
Rice, 4 sacks	44.00
Marine rope	2.75
Tender wage monthly	40.00
Sailors wage, 5 men	85.00
Oto wage	8.50
Diver boarding fee, 14 days in harbor	15.00
Lamp	2.10
Fishing line	1.70
Life line, $1\frac{3}{4}$-inch abacá rope	13.50
Cap leather, 1 set (used for air pump)	32.00
Patching cloth for diving dress, 2 yards	15.00
Diving dress	135.00
Shell wage paid to diver	43.60
Diver salary	30.00
Total	541.85

[For November, 1929.]

	Pesos.
Market expenses	57.00
Rice, 4 sacks	44.00
Miso and soy	4.50
Gin and tobacco	7.80
Pump oil, olive oil, 2 kilograms	2.50
Kerosene oil	1.70
Oar	2.00
Sailors wages, 5 men	88.00
Oto	7.50
Tender wage	40.00
Diver wage	30.00
Diver boarding expense at harbor	20.00
Anchor and shackle	18.60
Diving hose, one length, 9 fathoms (54 feet)	60.00
Shell wage to diver	63.80
Loss advance money to sailors, not returned	12.00
Medicine to crew	3.40
Total	462.80

Expenses for running a sailing boat with hand pump—Continued.

[For December, 1929.]

	Pesos.
Internal revenue tax	13.37
Market expenses	56.00
Rice, 4 sacks	44.00
Miso and soy	4.00
Pump oil	2.00
Fishing line	1.50
Patching cloth for diving dress, 2 yards	15.00
Gasoline, oil, and rubber-making solution	8.60
Diver salary	30.00
Diver boarding expense	20.00
Sailors salary, 5 men	87.00
Oto	7.00
Tender salary	40.00
Medical treatment expenses for crew	7.60
Bonus to crew	27.60
Tender bonus	10.00
Bonus to diver	40.00
Leather and lead, making diving shoe	17.50
Shell wage to diver	111.10
Total	542.02

Expenses per month for operating the "Rene," a pearler of 10.59 gross tons, equipped with sails and hand pump. Owned by Mr. Julius Schuck.

	Pesos.
Crew, 5 men	75
One tender	45
One supercargo	25
Miscellaneous expenses for crew	50
Rice, 6 sacks	66

One diver receives 10 pesos per picul of shells and 15 per cent of the pearls.

Average monthly expenses for running the *Rene*, 300 to 400 pesos.

THE PEARLING FLEET

The pearling yachts registered in Jolo are as follows: *Aki* (formerly *Rosario*), owned by Cañizares Cheong, now run by Matsui; *Shoun, Kotohira, Alexandra,* and *Cleopatra,* owned by the Sulu Pearling Co., Inc.; *Yamato,* owned by the Ohta Development Co.; *Inari,* owned by Salim Abubakar; *Englee,* owned by Stephen Jurika; *Nachimura,* owned by Chua Hock An; *Patholbab* (*Rasidia*), owned by Mora Kum Bu; *Rene,* owned by Julius Schuck; *Cherry* and *Yablogal Morad* (*Morad*), owned by P. J. Moore; *Sirena,* owned by Mora Go Tong.

The following pearlers are registered in Zamboanga: *Kumano,* owned by the Sulu Pearling Co., Inc.; *Koun, Happy,* and *Sumiyoshi,* owned by the Ohta Development Co.; *Thistle,* owned by James J. Wilson; *Mindanao,* owned by Cañizares Cheong, at present run by Arima; *Togo* and *Alice,* owned by F. Barrios, now run by Maehara; *San Francisco,* owned by F. Barrios; *Nautilus,* owned by Salim Abubakar.

These vessels are all two-masted yachts and vary in size from 6 to 14 tons. Five are equipped with Scripps driving motor and C. E. Heinke motor pump. These are *Aki, Cleopatra, Koun, Sumiyoshi,* and *Thistle.* The rest of the fleet use Heinke hand pump.

The boats carry a crew of from seven to thirteen men, as follows: Captain, tender, one or two divers, four or five sailors, one or two cooks, and two engineers. Each vessel is equipped with one complete diving gear, consisting of armor, pump, tubes or rubber hoses, weights, etc. The terms upon which the crew are engaged are not standardized. The following shows the varying wage scale:

	Pesos per month.
Captain	25–50
Tender	25–45
Sailor	15–20
Diver (The diver gets a bonus of 10 pesos per picul of shells and 15 to 20 per cent of the pearls.)	15–30

Under ideal conditions, a fairly well-constituted armored diver can make from two to three dives in an hour. The duration of the dive varies, since it primarily depends upon the constitution of the diver, the depth of the water, and the drift of the current. An experienced armored diver can remain under shallow water for almost an indefinite period, but in pearl fishing the practice is for the diver to work from ten to twenty minutes and rest for the same length of time. The rest is taken under water, about five fathoms below the surface, to enable the diver to readjust himself before he comes up to the boat. This is necessary, because any sudden change in pressure is usually fatal to him. The dive is limited in duration; ordinarily it is between fifteen and twenty-five minutes; it rarely exceeds thirty minutes. Diving is generally done during low tide or during the slack of the high tide, wherever possible. It is apparent, therefore, that the time spent by divers in actual work per month is comparatively short. Fifty to sixty hours represent the aver-

age monthly time spent in actual diving work per lugger, which correspond to three to four hours a day for from fifteen to eighteen days a month.

It is on record that during 1913 nine divers died; in 1914, seven; and in 1919, five, while working under water. The chief causes are inexperience and ambition to work in deep water, heart disease, syphilis, diver's paralysis, and accident through broken coupling. So far as known, no armored diver has suffered from the attack of sharks. Moro skin divers are occasionally bothered by these animals, but are never afraid of them and oftentimes emerge unscathed from the fight. No death among armored divers has been reported for 1929 and up to February 7, 1930.

PEARLS AND PEARL SHELLS OF SULU

Pearl fishing is the second most important industry in the Sulu Archipelago, which produces most of the shells and pearls for export from the Philippines. Moros, Chinese, Japanese, Christian Filipinos, and Americans are engaged in the business. The Sulu Pearling Co., Inc., and the Ohta Development Co. are the two largest pearling organizations. In Zamboanga, C. Boon Liat is the most prominent exporter of mother-of-pearl shells. There are several Chinese pearl merchants in Jolo, Siasi, Bongao, and Sitanki. The principal foreign markets for shells are Singapore and London; for pearls, Singapore, France, and London. Pearl dealers occasionally come to Zamboanga and Jolo.

During 1926, about 3,700 piculs of gold-lip pearl shells, valued at 149,166 pesos, were exported from Jolo. For 1929, the export in pearl shells amounted to 108,917 pesos. Most of these shells were sent to Sandakan, Singapore, and London. The apparent drop in the income was due to a fall in the price. At present the price of first-grade pearl shells is around 40 pesos per picul in Jolo and Zamboanga. The value of pearls obtained from Sulu waters could not be definitely ascertained, in as much as they are not all recorded. However, reliable persons estimated the total value of pearls taken in 1929 around 200,000 pesos. It was reported that last November a Moro sailor sold an 8-carat pearl to a Chinese in Jolo for 100 pesos. Tandico, one of the important Chinese merchants in the locality, bought it for 800 pesos. After a careful "doctoring," he was able to sell it to a Frenchman for 3,500 pesos. The true value of this rosy, 8-carat Sulu pearl, according to some Japanese and Chinese pearl merchants who had seen it, should be not less than 6,000 pesos.

PROTECTION OF SHELLS

The present survey has strengthened the conviction, which is held by many reliable informants, that in spite of the vigilance exercised by customs and internal-revenue officers the criminal custom of fishing undersized and immature shells is very common among skin divers as well as among armored divers. It was learned that young shells are gathered and, after being opened for the treasure they may contain, are thrown back into the water; and that divers open shells under the sea and leave them there, especially if they are undersized.

These practices are very hard to stop by governmental supervision, and can only be discontinued by the operators themselves. The operators should coöperate with the Government in protecting illegal-sized shells, for continuous indiscriminate taking of small pearl oysters would eventually bring about depletion of supply and the ruin of the industry.

The present method of measurement in limiting the minimum legal sizes for pearl shells is impractical and makes the alleged protection only apparent and not real. Shells that appear to be of legal size, but which are undersized in nacre measurement are fished and opened, only to be dumped into the sea. This is inevitable, since nacre measurement taken at right angles to the hinge joint is not feasible in practice. Divers work under conditions that make it impossible for them to use their power of discrimination and even if they can do so their criterion would be at best a big guess. Even on the deck of a pearler it is not easy to judge from the external dimension of a shell whether the nacre measurement is legal or not. The fact that the outer margin, or lip, varies in width, especially in young specimens, increases the percentage of probable error in shells that really need protection. It is obvious that pearl oysters are being destroyed in ignorance of their legal size, and many more will be sacrificed unless the method of protection is made practical. Legal size limit should be measured on the outside. To this end, the correlation between nacre measurement and external dimension was studied, and it has been found that *fourteen (14) centimeters, nacre measurement, taken at right angles to the hinge joint,* correspond, more or less, to *nineteen (19) centimeters, maximum outside long-axis measurement, taken at right angles to the base;* and *nine (9) centimeters, nacre measurement, taken at right angles to the hinge joint,* correspond to *eleven (11)*

centimeters, maximum outside long-axis measurement, taken at right angles to the base.

SUMMARY AND RECOMMENDATIONS

1. Pearl fishing in the Sulu Archipelago is primarily controlled by the two prevailing winds and tide drifts which occur periodically in Sulu waters. During the northeast monsoon, the northern beds cannot be profitably worked, and during the southwest monsoon, only a few of the southern banks can be successfully fished. When the tide drift is strong, the operation of pearl-shell fishing is suspended.

2. The division of the fisheries into north and south, in accordance with Department Order No. 7, has not only circumscribed the field of operation but also shortened the period of fishing, giving rise to a situation of considerable economic importance affecting both the boat owners and seamen. Upon the latter, particularly, the regulation works many individual hardships; and although it is true that individual hardships are inevitable to any readjustment, it is believed that the sacrifices in this case are not only unnecessary but unjustified. During the period of slack, the pearling crew is laid off and therefore deprived of its only means of livelihood, for these people are primarily brought up for sea life and cannot adapt themselves readily to land occupations. Consequently, they and their families are caused to suffer unnecessarily.

3. Observations indicate that there is no scarcity of shells in the Sulu pearl beds. Around the known banks, shells are obtained in waters ranging from 10 to 25 fathoms; and in waters of from 30 to 50 fathoms can be found a considerable number of pearl oysters that are rather difficult to secure; many of these remain in situ to constitute potential reserve nurseries from which the surrounding grounds are supplied.

4. The nine pearl beds in the Sulu Archipelago are extensive and in good condition, capable of sustaining the operation of a large pearling fleet.

5. At present the pearling fleet engaged in the waters of Mindanao and Sulu consists of twenty-four schooners, of which five are equipped with driving motor and motor-driven pump. It is believed that the present fleet is too small to do any serious damage to the fisheries.

6. Pearling boats do not as a rule work on the known grounds only, but as a matter of fact perform considerable prospecting.

7. New beds are being continually discovered.

8. Department Order No. 7 is a blanket restriction and has been found impractical. Its alleged protection is easily rendered futile, through lack of adequate enforcement.

9. That the continuity of pearl fisheries depends primarily upon natural events beyond the control of man is an established fact. The wind, the waves, the uncertain currents of the surrounding seas, and the geographical peculiarities of the banks influence the wanderings of the floating larvæ and the fate of spat-falls on the grounds. Therefore, it is apparent that, in the presence of these influences which alone can promote or facilitate the production of pearl oysters or cause the spawn to settle in favorable places, such an arbitrary remedy as devised in Department Order No. 7 is not only unnecessary but also unscientific.

10. In view of the above facts, it is recommended that Department Order No. 7 be rescinded.

11. It is further recommended that no protective measures for all beds or any banks within the Sulu Archipelago be adopted until after a careful study of the fisheries shall have been made.

12. It is also recommended that the regulation concerning the minimum legal sizes for pearl oysters be amended to read:

Margaritifera maxima Jameson (the gold-lip pearl shell). Nineteen centimeters, maximum outside long-axis measurement, taken at right angles to the base.

Margaritifera margaritifera Linnæus (the black-lip pearl shell). Eleven centimeters, maximum outside long-axis measurement, taken at right angles to the base.

ILLUSTRATIONS

PLATE 1

Map, showing the pearl-oyster beds of Mindanao and Sulu. (After Seale.)

PLATES 2 to 6. PHILIPPINE GOLD-LIP PEARL SHELL, MARGARITIFERA MAXIMA JAMESON

FIG. 1. Nacre measurement taken at right angles to the hinge joint.
2. Maximum outside long-axis measurement taken at right angles to the base.

PLATE 7. PHILIPPINE BLACK-LIP PEARL SHELL, MARGARITIFERA MARGARITIFERA LINNÆUS

FIG. 1. Nacre measurement taken at right angles to the hinge joint.
2. Maximum outside long-axis measurement taken at right angles to the base.

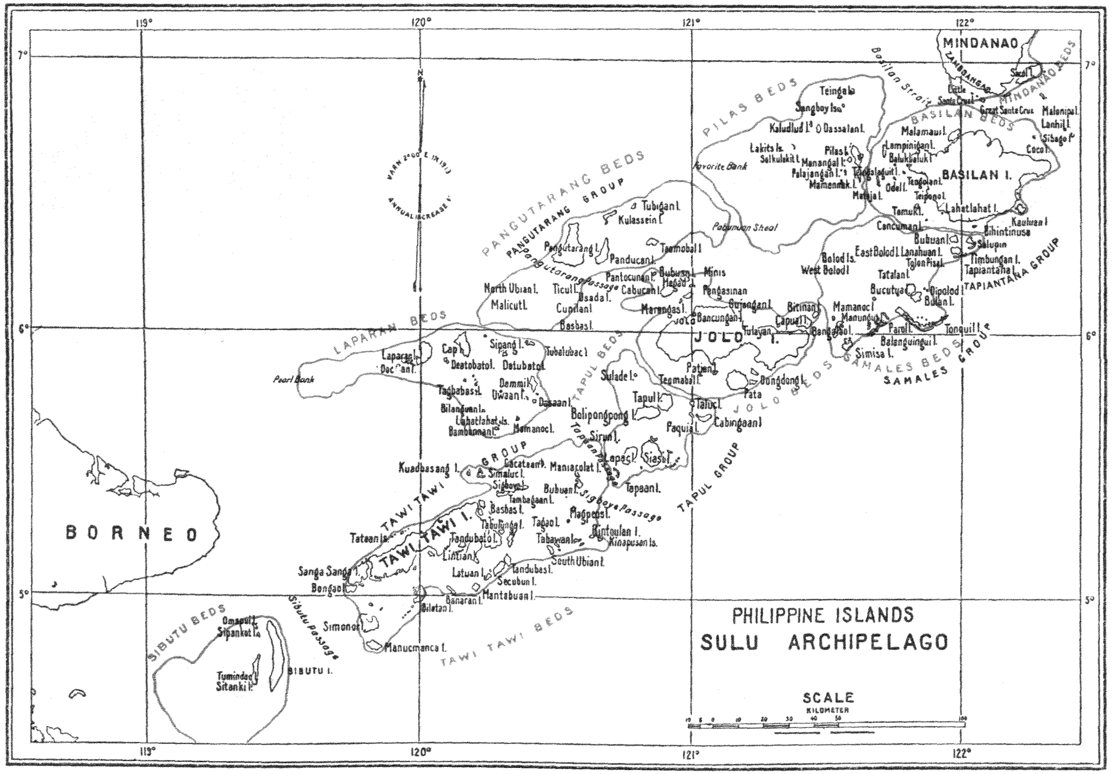

PLATE 1. THE PEARL-OYSTER BEDS OF MINDANAO AND SULU.

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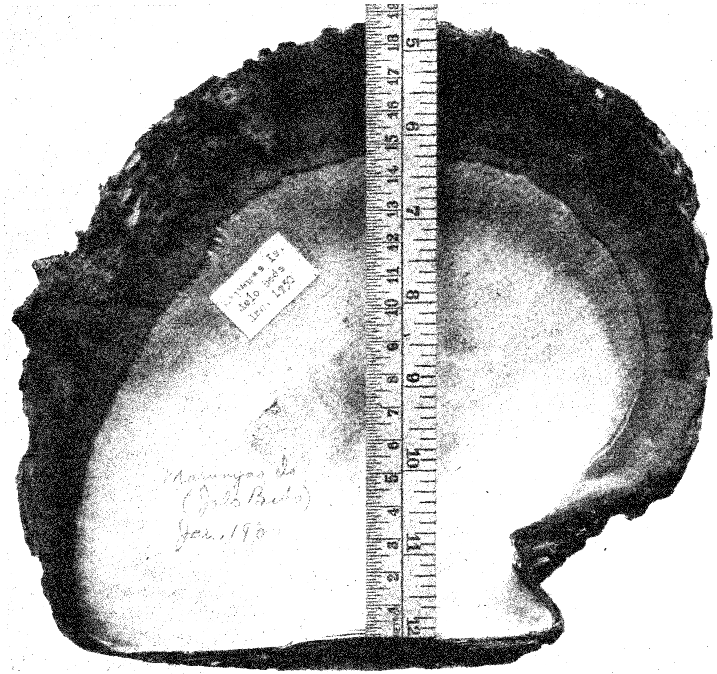
PLATE 2.



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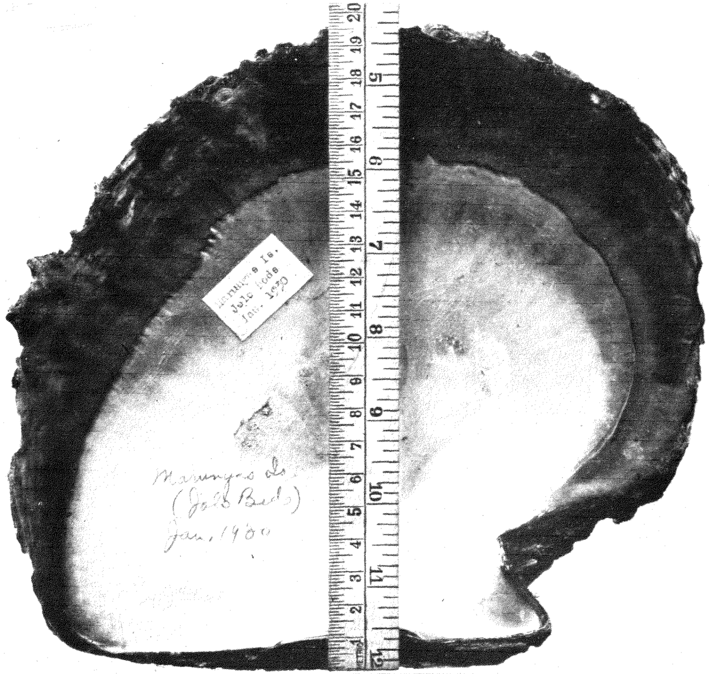

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PLATE 3.

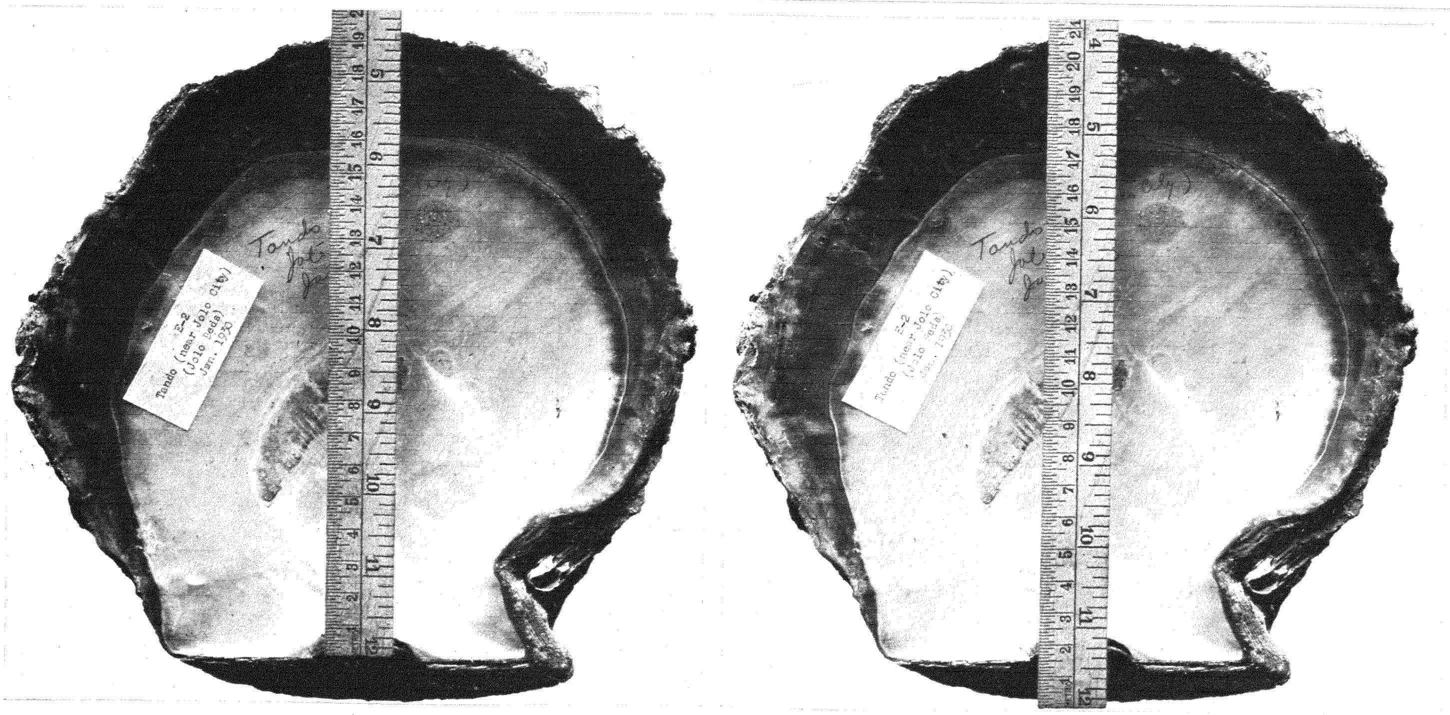

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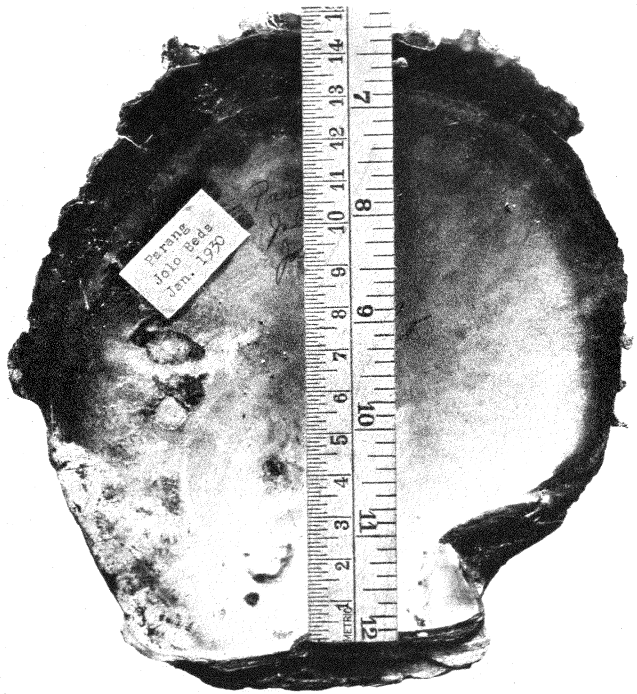
PLATE 4.



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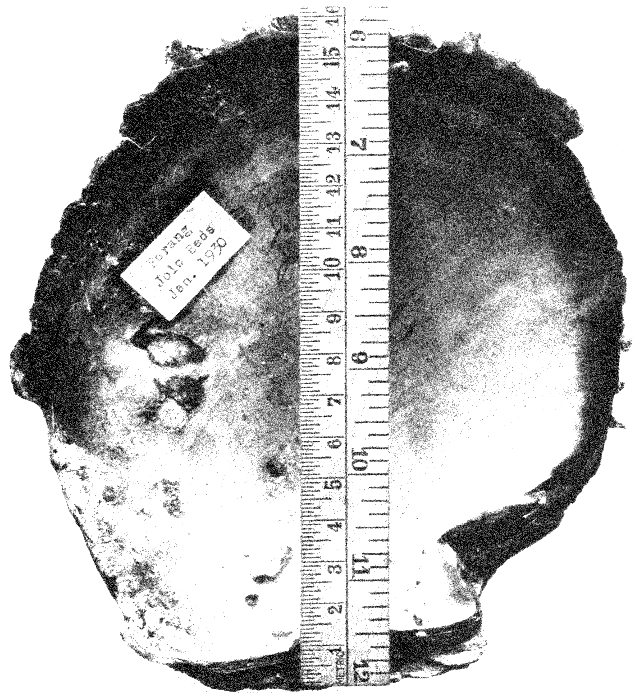

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PLATE 5.

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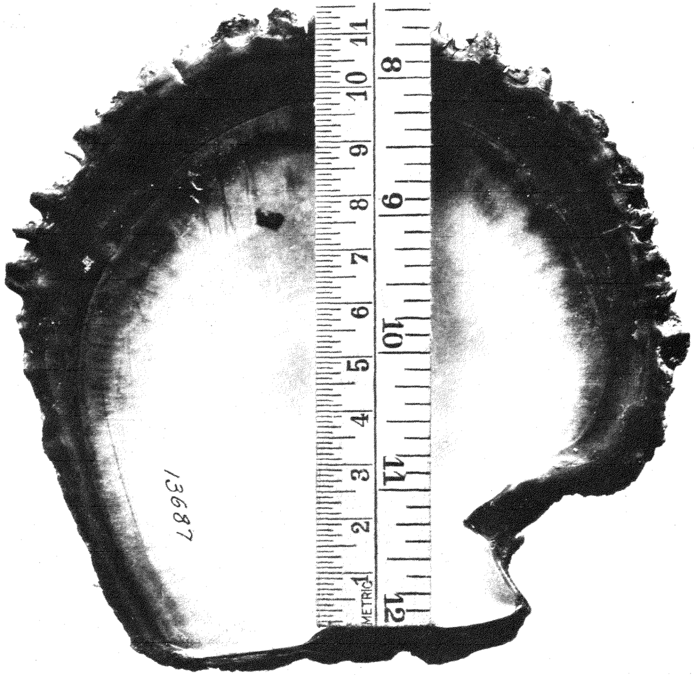
PLATE 6.



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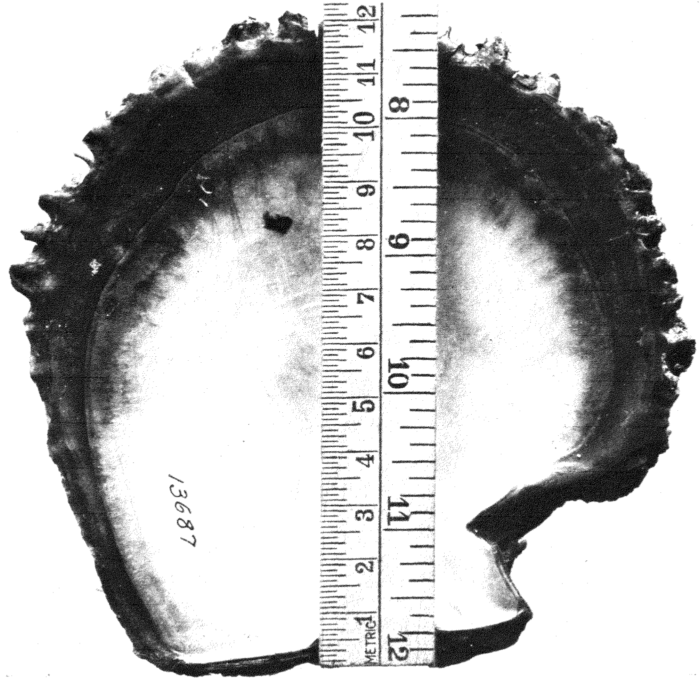

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PLATE 7.

NOTES ON MAYON VOLCANO

By LEOPOLDO A. FAUSTINO

Chief Geologist, Division of Geology and Mines, Bureau of Science, Manila

ONE TEXT FIGURE

The eruptions of Mayon Volcano were described in considerable detail in the writer's "Mayon Volcano and its Eruptions." [1] The following notes, based on observations made during a trip to the Mayon area from March 28 to 30, 1930, for purposes other than volcanic studies, are to describe the present condition of the volcano and to record certain features of the 1928 activity that were not fully reported in the first article.

It has been consistently reported by residents of Albay that Mayon is still "smoking." During the three days that the writer was in the district no ash was noted in the steam vapors, which were issuing from the crater lip and were visible from Legaspi and other neighboring towns. The vapors rise a short distance from the crater and then disappear. The best time for observation was found to be during the early morning or late afternoon, when cumulus clouds are absent.

The summit of the volcano presents a change in appearance, though not in outline. The rock streams, which were poured from the crater and found their way through some of the notches, as well as the avalanches from above, show a striking color contrast (reddish) to masses of old material (grayish), which can be seen in spots and stand out in such relief that apparently some of the blocks are ready to roll down to a more-secure place of repose. The crater is at the present time filled with volcanic material to the brim, although being of a pasty constitution it does not taper to a point, so that viewed from kilometer 9 of the Legaspi–Libog Road the crater appears filled with a plug somewhat like a dome. Between the plug and the rim of the crater is where the steam vapors issue forth, and more steam rises near the western rim than near the eastern rim.

[1] Philip. Journ. Sci. **40** (1929) 1–43, 21 pls., 3 text figs.

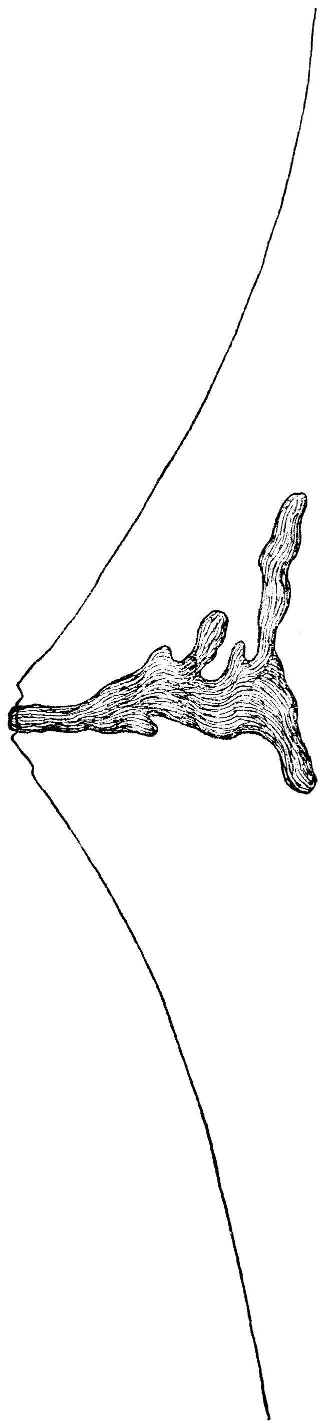

FIG. 1. Mayon Volcano, showing the direction and form of flow of the rock streams during the 1928 activity, viewed from kilometer 9, Legaspi—Libog Road.

The notch toward Libog now presents a wide open chute through which materials may come down from the crater, and it also shows the hardened volcanic domelike plug occupying the former depression. The main rock flow from this Libog notch took the form of a ridge, which sent out several lobelike branches upon reaching the more-level topography. Rain water from the crater following the main chute has dug a narrow channel on the top of the ridge, so that there is a stream valley in the making on top of a ridge. The direction and the form of the rock flow of the 1928 activity are shown in the accompanying figure (fig. 1).

The writer did not make any calculations of the amount of material exuded during the 1928 activity in the first article as it was in the midst of the rainy season when Mayon stopped sending forth solid materials, and the outline of the rock streams could not be made out through the rain clouds. His absence in Java during 1929 was the reason for his not making the observations the following year. Based upon what can now be seen resting on the slopes, together with what the floods have taken away, it is estimated that during the 1928 activity at least

150,000,000 cubic meters of materials were exuded by Mayon Volcano. A portion of this material obstructed about a kilometer of the Legaspi–Libog Road and had to be removed. A somewhat larger portion threatened the lines of the Manila Railroad and in some parts caused considerable damage. Another portion reached Albay Gulf, and the finer materials are being redeposited along the shores. Even far-off Lake Bato, in Camarines Sur, into which a stream flowing from the higher slopes of Mayon empties, is being over-run with sandy material. According to verbal reports of Messrs. Adams and Montalban, of the division of fisheries, Bureau of Science, the bottom of Lake Bato, which the people claim was formerly mud and silt, is now very sandy.

ILLUSTRATION

TEXT FIG. 1. Mayon Volcano, showing the direction and form of flow of the rock streams during the 1928 activity, viewed from kilometer 9, Legaspi–Libog Road.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), VIII [1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

THREE PLATES

The crane flies discussed in the present report are almost entirely from the mountains of Formosa, the majority being from Mount Hassen. As before, this extensive series of Tipulidæ was collected by my friend Prof. Syūti Issiki, to whom my deepest thanks are extended for the opportunity of studying these flies and retaining the material in my collection. A few additional Formosan species were collected by Doctor Shiraki and Mr. Sauter, as acknowledged in the text. Two species of *Dolichopeza* were taken in the mountains of Honshiu, Japan, by Messrs. Takahashi and Ūeno. A few additional species from western China, received through Mr. Herbert S. Parish, are discussed at this time. Except where noted to the contrary, the types of the novelties are preserved in my collection.

In order to supplement our scanty knowledge of the distribution of Formosan Tipulidæ, I am adding a complete list of the species taken by Professor Issiki on Hassensan, central Formosa, August 29 to 31, 1929, and October 21 to 26, 1929.

Tipulidæ from Hassensan, central Formosa, August 29 to 31 and October 21 to 26, 1929.

Dolichopeza (*Oropeza*) *shirakiella* (Alex.), 4,500 to 6,000 feet, August 30.
Tipula (*Tipula*) *yamata* Alex., 3,500 to 5,500 feet, October 22.
Limonia (*Discobola*) *margarita* (Alex.), 3,500 to 6,000 feet, August 31.
Limonia (*Discobola*) *taivanella* sp. nov., 6,500 to 7,500 feet, August 31; 7,500 feet, October 24.
Limonia (*Limonia*) *curvispina* Alex., 6,000 to 7,000 feet, August 30.
Limonia (*Limonia*) *ebriola* Alex., 5,600 feet, October 22.
Limonia (*Limonia*) *flavoterminalis* Alex., 6,000 feet, August 31.
Limonia (*Limonia*) *fraudulenta* Alex., 4,500 to 6,000 feet, August 30.
Limonia (*Limonia*) *koxinga* sp. nov., 4,500 to 6,000 feet, August 30.

[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

Limonia (*Limonia*) *remissa* Alex., 6,000 to 8,000 feet, October 23-24.

Limonia (*Libnotes*) *hassenana* sp. nov., 4,500 to 6,000 feet, August 30.

Limonia (*Rhipidia*) *formosana* (Alex.), 3,500 feet, October 24; 6,000 to 7,000 feet, August 30.

Limonia (*Rhipidia*) *triarmata* sp. nov., 4,500 to 6,000 feet, August 30.

Limonia (*Dicranomyia*) *depauperata* (Alex.), 3,500 feet, October 21.

Limonia (*Dicranomyia*) *nesomorio* (Alex.), 6,500 to 7,800 feet, October 26.

Limonia (*Dicranomyia*) *sordida* (Brunetti), 6,000 to 7,500 feet, August 30-31.

Limonia (*Dicranomyia*) *subpunctulata* sp. nov., 3,500 feet, October 21.

Limonia (*Geranomyia*) *alpestris* Alex., 6,500 to 7,800 feet, October 24.

Antocha (*Antocha*) *bifida* Alex., 3,600 feet, August 29.

Antocha (*Antocha*) *styx* sp. nov., 3,500 feet, October 24.

Helius (*Helius*) *attenuatus* Alex., 5,600 feet, October 22.

Helius (*Eurhamphidia*) *perelegans* sp. nov., 6,000 to 7,000 feet, August 30.

Thaumastoptera (*Taiwanita*) *issikiana* Alex., 5,600 feet, October 22.

Dicranoptycha issikina sp. nov., 3,500 to 5,500 feet, October 22.

Nipponomyia symphyletes (Alex.), 5,600 feet, October 22.

Tricyphona arisana Alex., 5,600 feet, October 22; 6,000 to 7,000 feet, August 30.

Tricyphona formosana Alex., 4,500 to 7,500 feet, August 30 and 31.

Dicranota (*Amalopina*) *delectata* sp. nov., 6,000 to 8,000 feet, October 23.

Dicranota (*Amalopina*) *gibbera* (Alex.), var., 4,500 to 6,000 feet, August 30.

Adelphomyia issikina sp. nov., 5,600 feet, October 22.

Epiphragma divisa Alex., 3,500 to 5,500 feet, October 22.

Pseudolimnophila autumnalis Alex., 5,600 to 7,800 feet, October 22 to 24.

Limnophila (*Prionolabis*) *serridentata* sp. nov., 3,500 to 8,000 feet, October 22 to 24.

Limnophila (*Dicranophragma*) *formosa* Alex., 6,000 to 7,000 feet, August 30.

Limnophila (*Dicranophragma*) *taiwanensis* Alex., 6,500 to 7,500 feet, August 31.

Atarba (*Atarbodes*) *fuscicornis* Edwards, 3,500 feet, October 21.

Atarba (*Atarbodes*) *leptoxantha* Alex., 6,000 to 7,000 feet, August 30.

Atarba (*Atarbodes*) *pallidicornis* Edwards, 4,500 to 6,000 feet, August 30; 3,500 to 5,600 feet, October 22.

Elephantomyia (*Elephantomyia*) *serotina* Alex., 6,500 to 7,800 feet, October 24.

Elephantomyia (*Elephantomyodes*) *uniformis* Alex., 4,500 to 6,000 feet, August 30.

Neolimnophila alticola Alex., 6,000 to 8,000 feet, October 23.

Toxorhina (*Ceratocheilus*) *taiwanicola* (Alex.), 3,500 to 7,000 feet, August 30 and 31.

Trentepohlia (*Mongoma*) *montina* sp. nov., 4,500 to 6,000 feet, August 30.

Gonomyia (*Progonomyia*) *confluenta* (Alex.), 3,500 to 5,500 feet, October 22.

Gonomyia (*Gonomyia*) *nansei* sp. nov., 3,600 feet, August 29; 2,500 to 5,600 feet, October 21 to 25.

Gonomyia (*Lipophleps*) *neonebulosa* sp. nov., 3,600 feet, August 29.

Dasymallomyia signata Brunetti, 3,500 feet, October 21.

Erioptera (*Empeda*) *liliputina* sp. nov., 3,600 feet, August 29.

Erioptera (*Empeda*) *minuscula* Alex., 3,600 feet, August 29; 3,500 feet, October 21.

Erioptera (*Ilisia*) *tenuisentis* Alex., 5,600 feet, October 22.

Ormosia anthracopoda sp. nov., 6,500 to 7,800 feet, October 26.

Molophilus arisanus Alex., 6,500 to 7,500 feet, August 31.

Molophilus nigritus Alex., 5,600 feet, October 22.

Styringomyia sinensis sp. nov., 2,500 to 3,500 feet, October 21 to 25.

Styringomyia taiwanensis sp. nov., 2,500 to 5,500 feet, October 21 to 25.

TIPULINÆ

DOLICHOPEZA (NESOPEZA) TARSALBA sp. nov.

General coloration black; antennæ short; terminal tarsal segments snowy white; wings tinged with blackish, the obliterative areas restricted; male hypopygium with the ninth tergite terminating in three blackened lobes, the median lobe long and slender; gonapophyses appearing as long, yellow, beaklike structures; eighth sternite only moderately enlarged, the caudal margin notched and bearing two pale lobes.

Male.—Length, about 11 millimeters; wing, 12.

Female.—Length, about 14 millimeters; wing, 13.

Frontal prolongation of head and palpi black. Antennæ of male much shorter than in *tarsalis;* scapal segments yellow, flagellum black; flagellar segments cylindrical, segments four to twelve of nearly equal length, the last segment about one-third the length of the penultimate; verticils shorter than the segments. Head yellowish brown, brighter in front, darkening to brown on posterior vertex and occiput.

Thorax chiefly brownish black, in the male with a paler median præscutal stripe; anterior dorsopleural region somewhat paler. Halteres obscure yellow, the knobs blackened. Legs with the coxæ blackened, their apices and the trochanters obscure yellow; femora, tibiæ, and basitarsi black, the femoral bases restrictedly pale; tips of basitarsi and remaining tarsal segments white. Wings with a strong blackish tinge, the oval stigma darker; a dark seam on anterior cord; obliterative areas very restricted, appearing as small areas before the stigma and across the fork of M; veins black, pale in the obliterative areas. Venation: Medial forks shallow.

Abdominal tergites brownish black, the basal sternites variegated with a broad, subapical, yellow annulus. Male hypopygium (Plate 2, fig. 25) relatively small. Ninth tergite (Plate 2, fig. 26) terminating in three blackened lobes, the median lobe slender, a little longer than the laterals. Gonapophyses (Plate 2, fig. 27) long and conspicuous, jutting from the genital chamber as yellow beaklike structures. Eighth sternite (Plate 2, fig. 28) with a deep U-shaped emargination that bears two small lobes.

Habitat.—Japan (Honshiu).

Holotype, male, Shirahone Hot Springs, Shinano, July 24, 1929 (*M. Ūeno.*) Allotopotype, female, with the type.

Dolichopeza (*Nesopeza*) *tarsalba* is most closely allied to *D.* (*N.*) *tarsalis* (Alexander), differing most conspicuously in the short antennæ of the male and details of structure of the male hypopygium.

DOLICHOPEZA (OROPEZA) SAITAMENSIS sp. nov.

General coloration brown, the præscutum with three slightly darker subnitidous stripes; head black; wings tinged with brown, with three creamy areas, the largest beyond the stigma; male hypopygium with the caudal margin of the ninth tergite a weakly chitinized pale flange, the median portion further produced into a quadrate plate.

Male.—Length, about 12 millimeters; wing, 13.5.

Frontal prolongation of head dark brown, paler laterally; palpi black. Antennæ with the scapal segments yellow, flagellar segments passing into dark brown; segments subcylindrical, the verticils relatively short and unilaterally arranged; terminal segment about two-thirds the penultimate. Head black, sparsely pruinose.

Mesonotum brown, the præscutum with three slightly darker brown, faintly shiny brown stripes; scutal lobes and scutellum dark brown; postnotum paler, with short yellow setæ. Pleura brownish testaceous. Halteres tinged with dusky. Legs with the coxæ and trochanters testaceous; remainder of legs passing into brown, the tarsi slightly paler yellow. Wings broad, tinged with brown, the stigma darker brown; cream-colored obliterative areas before and beyond the stigma, the latter very large; a third obliterative area across the base of cell 1st M_2; veins pale brown. Venation: Cell 1st M_2 relatively long and narrow.

Abdominal segments brown, indistinctly variegated with brownish yellow. Male hypopygium with the ninth tergite

(Plate 2, fig. 29) broad, the caudal margin appearing as a pale, weakly chitinized, narrow border, with a median quadrate extension that is produced into short lateral points; sublateral points slenderer; lateral arms unusually broad, the obtuse tips microscopically roughened. Outer dististyle a relatively short clavate lobe. Inner dististyle (Plate 2, fig. 30) distinctly bilobed at apex, the outer angle being produced into a slender rod, the remainder a broad, smooth, darkened blade.

Habitat.—Japan (Honshiu).

Holotype, male, Chichibu, Saitama, May 29, 1919 (*R. Takahashi*).

Dolichopeza (*Oropeza*) *saitamensis* is closest to the species *D.* (*O.*) *bispinula* (Alexander), differing in the structure of the male hypopygium, especially the armature of the ninth tergite.

LIMONIINÆ

LIMONIINI

LIMONIA (DISCOBOLA) TAIVANELLA sp. nov.

Allied to *argus;* wings with scattered brown dots in cells R and M, in addition to the ocellate pattern; male hypopygium with the caudal margin of the tergite produced into two blackened setiferous lobes that are separated by a quadrate notch; ventral dististyle an elongate-oval lobe.

Male.—Length, 6.5 to 7 millimeters; wing, 9 to 9.5.

Female.—Length, 7.5 to 8 millimeters; wing, 9 to 10.

Rostrum and palpi black, the former about one-half the remainder of head. Antennæ black, the segments with short pale apical pedicels. Head gray, variegated with blackish, the anterior vertex more silvery gray.

Pronotum greenish yellow, narrowly darkened laterally. Mesonotal præscutum olive yellow to yellow, the lateral margins brown, the median region more infuscated; scutal lobes brown; scutellum and postnotum yellow, sparsely pollinose. Pleura yellow, whitish pruinose, with two narrow brown stripes, the more dorsal extending from behind the fore coxæ, completely suffusing the pleurotergite; ventral stripe occupying the ventral sternopleurite; dorsopleural region dark, connected with the areas on the propleura and lateral margins of præscutum. Halteres black, the extreme base of stem and apical half of knob whitish. Legs with the coxæ and trochanters yellow; femora brownish yellow, the distal end light yellow, inclosing a narrow black subterminal ring that is nearly equal in width to the yellow apex; in some specimens, the basal portion of the femora is clearer yellow;

remainder of legs brownish yellow, the terminal tarsal segments passing into brownish black. Wings (Plate 1, fig. 1) yellow, with a brown ocellate pattern that is much as in *argus;* in addition, with scattered brown dots in cells R and M, these lacking in *argus.*

Abdominal tergites brown, the extreme caudal margins pale, in cases with a more yellow basal and medial ring on each segment; sternites greenish yellow, the caudal margins of the segments narrowly dark brown; hypopygium yellow. Male hypopygium (Plate 2, fig. 31) with the tergite, *9t,* narrowed apically, each lateral angle produced into a dusky setiferous lobe, these separated by a quadrate notch. Ventromesal lobe of basistyle, *b,* very stout, occupying almost the entire face of the style. Ventral dististyle, *vd,* an elongate-oval pale lobe that is approximately twice as long as the dorsal dististyle; rostral prolongation slender, darkened, the two pale peglike spines arising from face of style above. Dorsal dististyle with the surface microscopically roughened. Gonapophyses, *g,* with the apex of mesal apical lobe bluntly obtuse.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 6,500 to 7,500 feet, August 31, 1929 (*S. Issiki*). Allotopotype, female, altitude 7,500 feet, October 24, 1929 (*S. Issiki*). Paratopotypes, 2 males; paratype, 1 female, Shōrei, altitude 7,000 to 8,000 feet, October 25, 1928 (*S. Issiki*).

Limonia (*Discobola*) *taivanella* is separated from *L.* (*D.*) *argus* (Say) chiefly by the very different structure of the male hypopygium. The female from Shōrei had earlier been recorded as *argus.*[2] The Arisan record for *argus* in the preceding part under this general title[3] is correct, and there are unquestionably three species of *Discobola* inhabiting the higher mountains of Formosa.

LIMONIA (LIMONIA) KOXINGA sp. nov.

General coloration of thorax reddish yellow, unmarked; head blackish gray; halteres relatively short, brown; legs yellow, the femoral and tibial tips narrowly blackened; wings gray, darker basally, stigma brown; narrow dark seams along cord and outer end of cell 1st M_2; male hypopygium with the tergite deeply notched; dorsal dististyle lacking; rostral prolongation of ven-

[2] Philip. Journ. Sci. 40 (1929) 526.
[3] Philip. Journ. Sci. 42 (1930) 509.

tral dististyle long and slender; a spine arising from a long basal tubercle on face of dististyle near base; tergal valves of ovipositor very small.

Male.—Length, about 7.5 to 8 millimeters; wing, 7 to 7.4.

Female.—Length, about 8.5 to 9 millimeters; wing, 7.5 to 7.6.

Rostrum shiny black; palpi brownish black. Antennæ light brown; flagellar segments oval, becoming more slender and elongate outwardly, the verticils a little exceeding the segments; terminal segment a trifle shorter than the penultimate. Head blackish gray.

Pronotum reddish yellow, more blackened anteriorly above. Thorax uniformly reddish yellow, the surface nitidous, the pleura clearer yellow. Halteres relatively short, brown, the base of the stem yellow. Legs yellow, the femoral tips narrowly but conspicuously blackened; tibiæ more narrowly darkened; tarsi gradually darkened. Wings (Plate 1, fig. 2) slightly tinged with gray, the basal cells somewhat more strongly so; cells C and Sc more yellowish; stigma brown; narrow dark seams along cord and outer end of cell 1st M_2; veins black. Venation: Sc_1 ending opposite or just beyond midlength of Rs, Sc_2 at its tip; free tip of Sc_2 and R_2 about in alignment; m-cu at or close to the fork of M.

Abdominal tergites dark brown, the caudal margins narrowly pale; sternites and hypopygium paler. Male hypopygium (Plate 2, fig. 32) with the tergite, *9t*, deeply notched medially, the conspicuous lateral lobes with long conspicuous setæ. Basistyle, *b*, with the ventromesal lobe conspicuous. Ventral dististyle, *vd*, large and fleshy, much larger than the basistyle; rostral prolongation long and slender, curved; a single powerful spine arises from the face of the ventral dististyle near base of prolongation, this spine from a longer basal tubercle. No dorsal dististyle. Gonapophyses, *g*, with the mesal apical angle elongate, gradually expanded at tip into a weak spatula. Ovipositor with the tergal valves (cerci) very small.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 4,500 to 6,000 feet, August 30, 1929 (*S. Issiki*). Allotopotype, female. Paratopotypes 1 male, 1 female.

Limonia koxinga is named from Koxinga, piratic lord of Taiwan in the seventeenth century. The species is very different from *L.* (*L.*) *alticola* (Edwards) in the details of struc-

ture though very similar in the reduced tergal valves of the ovipositor.

LIMONIA (LIBNOTES) HASSENANA sp. nov.

Female.—Length, about 7 millimeters; wing, 7.5.

Generally similar and closely allied to *L.* (*L.*) *riverai* Alexander (Luzon), differing especially in the details of venation.

General coloration dark blackish gray. Halteres darkened, the base of the stem brightened. Legs with the femora obscure yellow, scarcely darkened at tips. Wings (Plate 1, fig. 3) with Rs long and gently arcuated; Sc ending opposite r-m and thus appearing very long, the distance between origin of Rs and Sc_2 subequal to R_{2+3} and exceeding R_3 alone; free tip of Sc_2 some distance before R_2, the latter arcuate. In the absence of the male, the length of the costal fringe in this sex cannot be stated.

Habitat.—Formosa.

Holotype, female, Hassensan, altitude 4,500 to 6,000 feet, August 30, 1929 (*S. Issiki*).

LIMONIA (RHIPIDIA) TRIARMATA sp. nov.

General coloration gray; antennæ with eight flagellar segments, each bearing two branches; terminal segment oval; wings gray, variegated with white spots and dots, the cubital and anal fields more uniformly gray; Sc_1 ending about opposite one-third the length of Rs; male hypopygium with three long spines on rostral prolongation of ventral dististyle.

Male.—Length, about 6 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ with flagellar segment one merely produced beneath, segments two to nine inclusive with two branches, the longest about twice the segments; flagellar segments ten and eleven merely produced; terminal segment relatively short, oval; basal enlargements and branches dark, the long glabrous apical necks pale, these necks shortening on outer segments, on the penultimate and antepenultimate very short. Head brownish gray.

Thorax gray, the præscutum with a median brown stripe, the lateral stripes lacking or nearly so. Halteres pale, the knobs weakly infuscated. Legs brown, the segments not conspicuously variegated. Wings (Plate 1, fig. 4) gray, variegated with white spots and dots, most evident in the radial and medial fields, the cubital and anal fields almost uniformly darkened; veins brownish black. Venation: Sc_1 ending about opposite one-third the length of Rs, Sc_2 not far from its tip; m-cu before the fork of M.

Male hypopygium (Plate 2, fig. 33) much as in *maculata;* rostral prolongation of ventral dististyle, *vd,* unusually long and slender, at near midlength with three long reddish spines from a restricted point, these spines a little shorter than the prolongation.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 4,500 to 6,000 feet, August 30, 1929 (*S. Issiki*).

Limonia (*Rhipidia*) *triarmata* is evidently closely allied to *L.* (*R.*) *maculata* (Meigen) and may prove to be a geographic race of the latter. I have seen a closely allied species or race from Szechwan, China.

LIMONIA (DICRANOMYIA) SUBPUNCTULATA sp. nov.

Allied to *punctulata;* wings without spots in costal and subcostal cells except at ends of cells; male hypopygium with the rostral prolongation of the ventral dististyle elongate, with two small basal spines; gonapophyses simple at tips.

Male.—Length, about 5 to 5.3 millimeters; wing, 6.

Female.—Length, about 6.5 to 7 millimeters; wing, 6.5.

Rostrum and palpi black. Antennæ black; flagellar segments oval, gradually decreasing in size outwardly. Head dark gray; anterior vertex narrow.

General coloration of thorax gray, the præscutum with a broad median brown stripe and less distinct lateral stripes; scutellum light gray. Halteres dusky, the knobs dirty white. Legs with the coxæ dark brown, pruinose; trochanters brown; femora gradually deepening to dark brown, the extreme tips narrowly obscure yellow; tibiæ and tarsi brownish yellow, the latter blackened at tips. Wings (Plate 1, fig. 5) cream-colored, with a restricted brown pattern, including spots at arculus; tip of Sc; R_2; at intervals along cord; outer end of cell 1st M_2 and tip of R_3; small spots at two-thirds the length of R_{4+5}, midlength of distal section of M_{1+2}, midlength of M, and two spots in cell 1st A adjoining vein 2d A; cells C and Sc without darkening except at each end of cells; veins yellow, dark brown in the infuscated areas. Venation: Sc_1 ending opposite origin of Rs, Sc_2 at tip; Rs straight, oblique; cell 1st M_2 elongate; m-cu at fork of M.

Abdomen dark gray, the caudal margins of the segments paler; basal sternites obscure yellow; hypopygium dark. Male hypopygium (Plate 2, fig. 34) with the lateral lobes of the ter-

gite, *9t*, low and obtuse, with numerous setæ. Basistyle, *b*, relatively small, the ventromesal lobe large. Ventral dististyle, *vd*, a large fleshy lobe, the rostral prolongation long and slender, at base with two small subequal spines that are less than one-half as long as the prolongation. Dorsal dististyle a gently curved chitinized rod, narrowed to the acute tip. Gonapophyses, *g*, with the mesal apical angle a simple acute spine.

Habitat.—Formosa.

Holotype, male, Meizi Hot Springs, foot of Hassensan, altitude 2,500 feet, October 25, 1929 (*S. Issiki*). Allotopotype, female, October 26, 1929 (*S. Issiki*). Paratopotypes, 20 males and females, with the type; paratypes, 1 male, Hassensan, altitude 3,500 feet, October 21, 1929 (*S. Issiki*); 1 male, Nōkō, altitude 8,000 feet, June 26, 1927 (*S. Issiki*).

Limonia (*Dicranomyia*) *subpunctulata* belongs to the *punctulata* group and has been confused with *punctulata* (de Meijere). The latter is figured by de Meijere as having a single rostral spine with its tip strongly curved; *L.* (*D.*) *fullowayi* (Alexander) has the rostral spine single, entirely straight, as long as the prolongation itself or longer. Gonapophyses with the mesal apical angle blackened, broad, more or less toothed.

LIMONIA (GERANOMYIA) APICIFASCIATA sp. nov.

General coloration reddish brown; rostrum black, the apical fourth yellow; halteres dusky; legs yellow; wings whitish hyaline with a heavy brown, chiefly costal pattern, the outermost area a complete fascia; male hypopygium with the two rostral spines arising from a long slender common tubercle.

Male.—Length, excluding rostrum, about 6 millimeters; wing, 6.8; rostrum, about 3.

Rostrum black, the apical fourth paling to yellow; palpi black. Antennæ with the scapal segments black; flagellum pale brown; flagellar segments with short inconspicuous verticils. Head gray, the anterior vertex more silvery, the posterior vertex more blackish.

Mesonotal præscutum brown, with four reddish brown stripes, the lateral portions more pruinose; scutum and scutellum pruinose, each scutal lobe with an elongate-triangular reddish brown area; postnotum pale brown, the surface pruinose. Pleura testaceous yellow. Halteres dusky, the base of the stem restrictedly yellow. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs yellow, only the terminal tarsal

segments infumed. Wings (Plate 1, fig. 6) whitish hyaline, the costal region pale yellow; a heavy brown, chiefly costal pattern; six major costal areas that extend into the cells behind, the third at origin of Rs, the last a complete, transverse, nearly apical fascia; between the major areas in cells C and Sc are smaller dark spots that restrict the ground color to small areas; additional restricted brown areas along cord and outer end of cell 1st M_2 and as marginal clouds at ends of longitudinal veins and at midlength of cell 2d A; veins yellowish brown, darker in the infuscated areas. Venation: Sc long, Sc_1 opposite the fork of Rs, Sc_2 at its tip; a supernumerary crossvein in cell Sc; m-cu at fork of M; vein 2d A short, strongly curved to margin, the cell wide.

Abdominal tergites reddish brown, more blackened medially and subapically, the caudal margin narrowly pale; sternites more uniformly yellow; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 35) with the tergite, *9t*, transverse, the caudal margin very gently emarginate. Basistyle, *b*, much smaller than the ventral dististyle, the ventromesal lobe large. Ventral dististyle, *vd*, oval, the rostral region large, produced into a very long tubercle that bears two slightly longer reddish spines. Dorsal dististyle a strongly curved sickle. Gonapophyses, *g*, with the mesal apical angle a strongly curved subacute spine.

Habitat.—Formosa.

Holotype, male, Shinten, December 3, 1928 (*S. Issiki*).

Limonia (*Geranomyia*) *apicifasciata* is very different from allied regional species of the subgenus.

ANTOCHA (ANTOCHA) STYX sp. nov.

General coloration dark gray; halteres and legs blackened; wings tinged with blackish; male hypopygium black, the outer dististyle pointed at apex; ædeagus broad.

Male.—Length, about 4.5 to 5 millimeters; wing, 5 to 5.5.

Rostrum and palpi black. Antennæ black; flagellar segments oval, gradually decreasing in size outwardly, the terminal segment about one-third longer than the penultimate; verticils very short, more conspicuous on basal and two outer segments. Head dark gray.

Mesonotum dark gray, the præscutum almost covered by still darker confluent stripes. Halteres infuscated, especially the knobs. Legs black. Wings (Plate 1, fig. 7) with a strong

blackish tinge; stigma a little darker; veins still darker brown. Venation: Sc_1 ending a short distance before the fork of the long Rs; cell 1st M_2 closed.

Abdomen blackish gray, the hypopygium black. Male hypopygium (Plate 2, fig. 36) with the caudal margin of the tergite, *9t,* gently emarginate. Surface of basistyle, *b,* with very numerous course setæ. Outer dististyle chitinized, curved gently to an acute point, the face carinate. Inner dististyle very strongly curved. Ædeagus, *a*, broad.

Habitat.—Formosa.

Holotype, male, Meizi Hot Springs, foot of Hassensan, altitude 2,500 feet, October 26, 1929 (*S. Issiki*). Paratopotypes, 3 males, October 25, 1929 (*S. Issiki*); paratypes, 2 males, Hassensan, altitude 3,500 feet, October 24, 1929 (*S. Issiki*).

Antocha styx is readily told from all described regional species by the diagnostic features listed above.

HELIUS (EURHAMPHIDIA) PERELEGANS sp. nov.

Female.—Length, about 5.5 millimeters; wing, 5.5.

Allied to *H.* (*E.*) *inelegans* Alexander, differing especially in the venational details and pattern of the legs.

Mesonotal præscutum with the disk almost covered by three confluent brown stripes, restricting the ground color to the humeral and lateral portions; scutal lobes dark brown. Femora with the tips rather broadly and conspicuously snowy white; tibial bases narrowly pale, the tips very broadly white; tarsi white, the terminal tarsal segments darkened. Wings (Plate 1, fig. 8) with Sc short, Sc_1 ending opposite r-m, Sc_2 a little longer than Sc_1; Rs short and straight; m-cu before the fork of M.

Habitat.—Formosa.

Holotype, female, Hassensan, altitude 6,000 to 7,000 feet, August 30, 1929 (*S. Issiki*).

DICRANOPTYCHA ISSIKINA sp. nov.

General coloration of thorax brown, the præscutum with four narrow shiny black stripes, the scutal lobes further variegated with similar areas; legs yellow; wings gray, the prearcular and costal regions clear yellow; stigma elongate, brown; veins yellow, narrowly bordered on the membrane by the same color.

Male.—Length, 8.5 to 9.5 millimeters; wing, 9 to 10.5.

Rostrum brownish gray; palpi dark brown. Antennæ reddish brown, the first segment darker at base; basal flagellar segments with long conspicuous verticils, these shorter on the outer segments. Head dark brownish gray.

Mesonotal præscutum grayish brown to brown, more grayish laterally, with four narrow and incomplete shiny black stripes, the intermediate pair longer and broader; scutum brownish gray, each lobe with two shiny black areas; scutellum brownish gray, the postnotal mediotergite clearer gray. Pleura gray. Halteres yellow, the knobs a little dusky. Legs with the coxæ and trochanters brownish yellow; remainder of legs clearer yellow, with dark setæ, the outer tarsal segments darkened. Wings (Plate 1, fig. 9) gray, the prearcular and costal regions clear yellow; stigma elongate, dark brown; veins yellow, narrowly bordered on membrane by clear yellow. Venation: Rs angulated and short-spurred at origin, longer than cell 1st M_2; m-cu at before midlength of the latter.

Abdominal tergites obscure yellow, with a dorsomedian brown line; sternites clearer yellow; a conspicuous subterminal blackish gray ring involving segments six to eight; hypopygium fulvous. Male hypopygium (Plate 2, fig. 37) with the tergite transverse, the ventrolateral angles produced caudad into spatulate pale blades (lateral processes). Outer dististyle, *od*, terminating in a slender black point, the surface with abundant erect yellow setulæ, the disk and inner margin with longer recurved setæ. Inner dististyle, *id*, longer, set with spinous setæ. Gonapophyses small, slender, shorter than the bifid ædeagus, *a*.

Habitat.—Formosa.

Holotype, male Hassensan, altitude 3,500 to 5,500 feet, October 22, 1929 (*S. Issiki*). Paratopotype, male.

I take great pleasure in naming this beautiful *Dicranoptycha* in honor of the collector, Prof. Syūti Issiki, distinguished student of the Mecoptera of eastern Asia. The species is very distinct from all other members of the genus so far discovered in eastern Asia.

PEDICIINI

DICRANOTA (AMALOPINA) DELECTATA sp. nov.

General coloration pale yellow, including the legs and halteres; wings cream yellow, with a conspicuous brown pattern that includes the prearcular cells and darkened costa as far distad as the origin of Rs; supernumerary crossveins in cells R_1 and R_3; cell 1st M_2 closed.

Male.—Length, about 6 millimeters; wing, 7.

Rostrum and palpi brown. Antennæ 14-segmented; basal segment black, the remaining segments pale testaceous brown. Head ocherous, the vertex a little darkened.

Mesonotal præscutum pale yellow, with a whitish bloom; scutal lobes more darkened; scutellum and postnotum pale yellow, with a whitish bloom. Pleura pale yellow. Halteres yellow. Legs yellow, the two terminal tarsal segments brown. Wings (Plate 1, fig. 10) pale cream yellow, with a conspicuous brown pattern; prearcular region and cells C and Sc darkened to approximately opposite the origin of Rs; base of cell R darkened to opposite Sc_2; stigmal region diffusely darkened; narrow but conspicuous dark brown seams at origin of Rs, along cord and outer end of cell 1st M_2, on R_2 and the supernumerary crossvein in cell R_3, at the tips of veins R_{1+2} and R_3, and at fork of M_{1+2}; veins yellow, brown in the infuscated areas. Venation: A supernumerary crossvein in cell R_1; Rs strongly arcuated at origin; a supernumerary crossvein in cell R_3 more than its own length beyond R_2; cell 1st M_2 closed.

Abdomen with the basal segments yellow, ringed caudally with brown, the amount increasing on the outer segments; outer segments, including the hypopygium, more uniformly dark brown.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 6,000 to 8,000 feet, October 23, 1929 (*S. Issiki*).

Dicranota (*Amalopina*) *delectata* is most nearly allied to *D.* (*A.*) *dicranotoides* (Alexander) and *D.* (*A.*) *sibirica* (Alexander), differing in the wing pattern and venation.

ADELPHOMYIA ISSIKINA sp. nov.

General coloration of notum ocherous, marked with brown; knobs of halteres infuscated; legs yellow, the femoral tips conspicuously blackened; wings with the costal third cream-colored, the remainder conspicuously darkened; a sparse but heavy wing pattern; abundant macrotrichia in cells of wing beyond cord; R_2 far before fork of R_{3+4}; cell M_1 present.

Female.—Length, about 5.5 millimeters; wing, 6.

Rostrum reddish brown; palpi black. Antennæ 16-segmented, black, the flagellar segments a little paler; flagellar segments becoming more slender and elongated; verticils conspicuous. Head light brown.

Pronotum dark brown, paler behind. Mesonotum ocherous to reddish brown, the præscutum with a more or less distinct median brown stripe; scutal lobes darkened; scutellum and postnotum dark brown. Pleura chiefly dark brown, the sternopleurite, meral region, and pleurotergite more yellowish. Hal-

teres pale, the knobs infuscated. Legs with the fore coxæ infuscated, the remaining coxæ and trochanters yellow; femora yellow, the tips narrowly blackened; tibiæ yellow, the tips very narrowly blackened; tarsi yellow, passing into brown; tibial spurs distinct. Wings (Plate 1, fig. 11) with the costal third cream-colored, the central and posterior thirds darkened, the anal cells again somewhat more yellowish; a heavy dark brown pattern, arranged as follows: Origin of Rs; stigma; along cord and outer end of cell 1st M_2; veins yellow, more infuscated in the darkened regions. Abundant macrotrichia in the cells of the wing beyond the cord. Venation: Sc_1 ending nearly opposite the fork of Rs, Sc_2 some distance from its tip; Rs angulated and spurred at origin; R_2 more than one-half its length before the fork of R_{3+4}; cell M_1 present; m-cu at near midlength of cell 1st M_2; vein 2d A nearly straight.

Abdominal tergites dark brown; sternites brown basally, the caudal half obscure yellow, the amount of the latter decreasing on the outer segments. Ovipositor with the basal shields blackened; valves yellow, the sternal valves blackened ventrally.

Habitat.—Formosa.

Holotype, female, Hassensan, altitude 5,600 feet, October 22, 1929 (*S. Issiki*). Paratopotype, female.

Adelphomyia issikina is another of the very distinct species of crane flies discovered by the collector in the mountains of Formosa. I take great pleasure in dedicating the present fly to Professor Issiki who has done so much toward making known the rich tipulid fauna of the island. The present species is very distinct from all regional forms. I would believe that *Oxydiscus* de Meijere [4] is identical with *Adelphomyia,* despite the implied lack of tibial spurs, a highly variable character in this, as well as other groups of Tipulidæ.

HEXATOMINI

LIMNOPHILA (PRIONOLABIS) SERRIDENTATA sp. nov.

General coloration black, the surface opaque by a sparse pruinosity; wings grayish with vague seams on the crossveins and deflections; Sc_1 much longer than Sc_2; R_{2+3} from one-half to two-thirds R_3; cell M_1 lacking; m short and straight, less than the basal section of M_3; male hypopygium with the gonapophyses serrate along outer margin.

[4] Tijdschr. voor Entomologie 56 (1913) 350–351.

Male.—Length, about 4.3 to 5 millimeters; wing, 5 to 6.2.

Female.—Length, about 4.8 to 5.2 millimeters; wing, 5.5 to 6.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, gradually decreasing in size outwardly, the terminal segment little larger than the penultimate; longest verticils unilaterally arranged, exceeding the segments in length. Head black, pruinose.

Thorax black, the surface pruinose, least so on the median region of præscutum. Halteres pale yellow, in cases with the knobs weakly infuscated. Legs with the fore coxæ darkened, the remaining coxæ and all trochanters yellow; femora yellow, the tips blackened; tibiæ and basitarsi similar, the tips more narrowly blackened; remainder of tarsi black; legs conspicuously hairy. Wings (Plate 1, fig. 12) grayish, the stigma and vague seams at origin of Rs, along cord and outer end of cell 1st M_2 slightly darker; veins light brown. Venation: Sc_1 ending shortly before fork of Rs, Sc_2 some distance from its tip; R_2 subequal to R_{1+2}; R_{2+3} approximately one-half to two-thirds R_3 alone; cell M_1 lacking; m straight, transverse, shorter than the arcuated basal section of M_3; m-cu close to or before midlength of cell 1st M_2.

Abdomen black, including the hypopygium, the surface more or less pruinose. Male hypopygium (Plate 3, fig. 38) with the inner dististyle, *id*, dilated at base, the outer surface with numerous erect setæ, the apex suddenly narrowed into a blackened point. Gonapophyses, *g*, appearing as slender blackened plates, the outer margin conspicuously serrate. Ædeagus, *a*, narrow, gently curved.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 6,500 to 7,800 feet, October 24, 1929 (*S. Issiki*). Allotopotype, female. Paratopotypes, 16 males and females, altitude 3,500 to 8,000 feet, October 22 to 24, 1929 (*S. Issiki*).

Limnophila (*Prionolabis*) *serridentata* is obviously closely allied to *L.* (*P.*) *liponeura* Alexander and *L.* (*P.*) *lipophleps* Alexander, of Kiushiu, Japan, differing most evidently in the structure of the male hypopygium. The somewhat similar *L. nigronitida* Edwards, likewise from the high mountains of Formosa, differs in the polished black thoracic notum and in a number of important venational characters, as the position of Sc_2, the subequal R_{2+3}, and the long oblique m.

ERIOPTERINI

TRENTEPOHLIA (MONGOMA) MONTINA sp. nov.

General coloration dark brown; legs black, the tips of the tibiæ and the tarsi paling to yellow; wings tinged with dusky; R_2 shortly before fork of R_{3+4}; fusion of Cu_1 and 1st A slight.

Male.—Length, about 6 millimeters; wing, 6.5.

Female.—Length, about 7 millimeters; wing, 6.4.

Rostrum and palpi dark brown. Antennæ black; flagellar segments with verticils of moderate length. Head black, very sparsely pruinose.

Mesonotum dark brown, the posterior margin of the scutellum and posterior half of the postnotal mediotergite more yellowish. Pleura yellowish brown, the dorsopleural region more blackish. Halteres brownish black, the base of the stem restrictedly pale. Legs with the fore coxæ dark brown, the remaining coxæ more yellowish brown; trochanters obscure yellow; femora black; tibiæ black, the tips paling to dirty yellow; tarsi yellow. Wings (Plate 1, fig. 13) with a strong dusky tinge, the stigma darker but small and ill-defined; veins brownish black. Venation: R_2 shortly before fork of R_{3+4} ; m-cu at or just before the fork of M; fusion of Cu_1 and 1st A slight.

Abdomen brownish black, the sternites paler, especially in the male.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 4,500 to 6,000 feet, August 30, 1929 (*S. Issiki*). Allotopotype, female.

It is probable that the present species will be found to be a characteristic mountain form. It was associated with typical Palæarctic crane flies, as *Tricyphona formosana* Alexander and *Dicranota* (*Amalopina*) *gibbera* (Alexander), var.

GONOMYIA (PROGONOMYIA) CONFLUENTA (Alexander).

Gnophomyia confluenta ALEXANDER, Ann. Ent. Soc. America 17 (1924) 69.

Two males from Hassensan, altitude 3,500 to 5,500 feet, October 22, 1929 (*S. Issiki*). The venation (Plate 1, fig. 14) shows a long Sc, Sc_1 ending opposite the fork of Rs or nearly so, Sc_2 at near middistance between origin of Rs and tip of Sc_1; cell R_3 relatively deep; m-cu at or close to the fork of M.

The male hypopygium (Plate 3, fig. 39) has the outer lobe of the basistyle, *b*, stout. Three dististyles, the outer a slender curved rod from an enlarged base; second dististyle bifid at

apex, the stem with erect conspicuous setæ; inner style simple, stouter than the first, the apex obtuse. Ædeagus, *a*, compressed.

The species is very different from *G.* (*P.*) *scutellum-album* Alexander, likewise from the Formosan mountains, in the uniformly black coloration and very different male hypopygium.

GONOMYIA (GONOMYIA) NANSEI sp. nov.

General coloration dark brown; rostrum and antennæ black; head dark gray; pleura yellow, more or less distinctly variegated with brown; halteres dusky; legs brown; wings gray, the stigmal region more infuscated; male hypopygium with the outer dististyle a slender setiferous rod; phallosome with three spinous points.

Male.—Length, about 3.5 to 4 millimeters; wing, 4.5 to 5.

Female.—Length, about 4.5 to 4.8 millimeters; wing, 5 to 5.4.

Rostrum and palpi black. Antennæ black throughout, the outer flagellar segments very slender. Head dark gray.

Pronotum and anterior lateral pretergites light sulphur yellow. Mesonotum dark brown, very sparsely pruinose, the lateral and humeral regions of the præscutum yellow; scutellum light sulphur yellow; postnotal mediotergite gray. Pleura yellow, with more or less distinct darkened areas on the anepisternum and on ventral sternopleurite. Halteres elongate, dusky, the extreme base of stem yellow. Legs with the coxæ brownish testaceous; trochanters yellow; remainder of legs pale brown, the outer tarsal segments deepening to black. Wings (Plate 1, fig. 15) gray, the stigmal region more infuscated; veins darker brown. Venation: Sc_1 ending just beyond origin of Rs, Sc_2 close to its tip; cell 1st M_2 closed; m-cu at or close to fork of M.

Abdominal tergites brownish black, the sternites more yellowish. Male hypopygium (Plate 3, fig. 40) with the outer dististyle a slender setiferous rod. Inner dististyle, *id*, a flattened chitinized plate, the outer lateral angle produced into a curved blackened spine, the inner lateral angle less produced; mesal margin produced into a fleshy setiferous lobe. Phallosome, *p*, with three blackened spines, two apparently borne by an apophysal structure, the third at apex of ædeagus.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 5,600 feet, October 22, 1929 (*S. Issiki*). Allotopotype, female. Paratopotypes, 1 male, altitude 3,600 feet, August 29, 1929; 4 males and females, altitude 2,500 to 5,600 feet, October 21 to 25, 1929 (*S. Issiki*).

The specific name, *nansei,* is that of a local Formosan tribe. The fly is distinguished from all similar regional species by the structure of the male hypopygium.

GONOMYIA (LIPOPHLEPS) SAUTERI sp. nov.

General coloration dark brown; rostrum, palpi, and antennæ black; head gray; pleura dark, with a silvery white longitudinal stripe; halteres dusky; wings unmarked except for a diffuse stigma; Sc long; male hypopygium with two dististyles, the outer terminating in an acute blackened point.

Male.—Length, about 3.3 millimeters; wing, 4.1.

Rostrum and palpi brownish black. Antennæ black throughout; flagellar segments elongate, clothed with a long erect white pubescence, in addition to the longer unilaterally arranged verticils. Head dark gray, with a small yellow area on the posterior vertex.

Pronotum and anterior lateral pretergites light sulphur yellow. Mesonotal præscutum and scutal lobes uniformly dark grayish brown; median region of scutum and the scutellum except for a basal darkening obscure yellow; postnotum dark, heavily pruinose, the anterolateral portions more yellowish. Pleura dark, with a broad silvery white longitudinal stripe, extending from and including the fore coxæ, reaching the abdomen; pleurotergite chiefly yellow. Halteres dusky, including the knobs. Legs with the fore coxæ as described, the other coxæ darker, their tips pale; trochanters testaceous yellow; femora brownish yellow, passing into darker brown at tips; tibiæ and tarsi uniform brown. Wings (Plate 1, fig. 16) with a brownish tinge, the prearcular and costal regions more yellowish; the very diffuse stigma a little darker than the ground color; veins brown. Venation: Sc long, Sc_1 extending to shortly before midlength of the long Rs, Sc_2 some distance from its tip; branches of Rs strongly divergent; R_5 and M_{1+2} deflected toward one another at margin, narrowing the cell; cell 1st M_2 narrowed at base.

Abdominal tergites uniformly dark brown, the hypopygium more yellowish. Male hypopygium (Plate 3, fig. 41) with two dististyles, the outer, *od,* a slender rod that gradually narrows to an acute blackened point, the base of the latter with numerous setæ. Inner dististyle a small pale lobe that is a little shorter than the apical lobe of the basistyle, terminating in a fasciculate bristle and with a very long slender seta on outer margin beyond

midlength. Phallosome, *p*, appearing as a broad pale plate, the surface laterally with abundant microscopic setulæ, the tip produced into a glabrous portion; two additional elongate rods, the shorter from an enlarged base.

Habitat.—Formosa.

Holotype, male, Daitotei, April 1914 (*H. Sauter*).

Type in the collection of the Deutsches Entomologisches Museum.

Gonomyia (*Lipophleps*) *sauteri* is named in honor of Mr. H. Sauter, well-known collector of Formosan insects. The species is very distinct from *G.* (*L.*) *longiradialis* Alexander (Luzon) and *G.* (*L.*) *skusei* Alexander (eastern Australia) in the structure of the male hypopygium. This is very probably the species recorded as *skusei* (*gracilis* Skuse, preoccupied) by Riedel[5] from Macuyama, Formosa.

GONOMYIA (LIPOPHLEPS) NEONEBULOSA sp. nov.

General coloration dark brownish gray; pleura dark, with a yellowish white longitudinal stripe; femora brownish black; wings gray, variegated with brownish gray; costal region pale yellow; abdomen grayish black, the caudal margins of the segments narrowly yellow.

Female.—Length, about 4.5 millimeters; wing, 4.1.

Rostrum and palpi black. Antennæ with the scapal segments obscure orange; flagellum black. Head orange, the disk of the vertex darkened.

Pronotum and anterior lateral pretergites light yellow, the former darkened laterally. Mesonotum dark brownish gray, the caudal margin of the scutellum broadly yellow; postnotal mediotergite pale, with a little less than the distal half darkened. Pleura dark, with a broad, yellowish white, longitudinal stripe extending from and including the fore coxæ, passing beneath the halteres to the abdomen; dorsal pleurites brown, the ventral sclerites more bluish gray. Halteres with the stem dusky at base, the distal half yellow; knobs dusky, the ends conspicuously yellow. Legs with the fore coxæ yellow; remaining coxæ similar, the bases narrowly darkened; femora brownish black beyond the base, the extreme tips on lower surface a little brightened; tibiæ and tarsi brownish black. Wings (Plate 1, fig. 17) with the ground color gray, variegated with darker brownish gray clouds; cells C and Sc pale yellow; stigma not darker than the

[5] Archiv für Naturgeschichte 82 for 1916, Abteil. A (1917) 112.

remaining dark areas; darkened clouds occupying most of radial field, except an area in outer end of cell R; other fields of wing merely streaked with dark; veins brown, Sc yellow. Venation: Sc_1 ending some distance before origin of Rs, the latter vein sinuous at end; anterior branch of Rs relatively long and straight, cell R_2 being nearly parallel; m-cu close to fork of M.

Abdomen grayish black, the caudal margins of the segments narrowly yellow.

Habitat.—Formosa.

Holotype, female, Meizi Hot Springs, foot of Hassensan, altitude 2,500 feet, October 25, 1929 (*S. Issiki*). Paratopotype, female; paratype, 1 sex?, Hassensan, altitude 3,600 feet, August 29, 1929 (*S. Issiki*).

By Edwards's key to the Oriental species of *Lipophleps*[6] the present species runs to *G.* (*L.*) *robinsoni* Edwards, of the Federated Malay States, differing in slight details of coloration and venation.

GONOMYIA (LIPOPHLEPS) SINUOSA sp. nov.

General coloration brown; basal segments of antennæ orange; head yellow, the center of the vertex blackened; a conspicuous silvery longitudinal stripe on pleura; legs brownish yellow, the tarsi passing into black; wings brownish yellow, the stigmal and axillary regions a little darkened; anterior branch of Rs sinuous on distal third.

Female.—Length, about 5 millimeters; wing, 4.5.

Rostrum and palpi black. Antennæ with scapal segments orange, the flagellum black. Head yellow, the center of the vertex blackened.

Pronotum and anterior lateral pretergites light sulphur yellow, the former dark brown on sides. Mesonotum light brown, slightly darker medially; scutal lobes brown, the median region yellow; scutellum brown, narrowly margined caudally with paler; postnotum pale, sparsely pruinose. Pleura light brown, with a conspicuous silvery white longitudinal stripe extending from behind the fore coxæ to the base of the abdomen, this passing beneath the halteres; the stripe is margined both above and below by a narrower infuscated line; ventral sternopleurite and dorsal pleurites, including the pleurotergite, more buffy yellow. Halteres yellow, the knobs a little more obscure. Legs with the coxæ and trochanters yellow; femora obscure brownish yellow,

[6] Journ. Fed. Malay St. Mus. 14 (1928) 104–105.

the tibiæ gradually darkening; tarsi passing into black. Wings (Plate 1, fig. 18) with a faint brownish yellow tinge; costal region clearer yellow; stigma appearing as a longitudinal dusky streak in cell R_2, the remainder of the region yellow; axillary region a little darkened; outer ends of the radial cells slightly darkened; veins pale brown, Sc yellower. Venation: Sc short, Sc_1 ending some distance before the origin of Rs, the latter angulated at origin; anterior branch of Rs sinuous, the distal third arcuate and evidently marking the point of departure of a small cephalic branch, R_3, normally present in the *sulphurella* group; m-cu shortly before the fork of M.

Abdominal tergites brown, the segments narrowly margined caudally with pale yellow; sternites more yellowish, the caudal margins narrowly paler yellow, the lateral margins narrowly infuscated, most distinct on the basal segments.

Habitat.—Formosa.

Holotype, female, Meizi Hot Springs, foot of Hassensan, altitude 2,500 feet, October 25, 1929 (*S. Issiki*).

Gonomyia (*Lipophleps*) *sinuosa* is well distinguished from other regional species by the details of coloration and venation. The course of the anterior branch of Rs is very peculiar and suggestive.

CRYPTOLABIS (BAEOURA) TRICHOPODA sp. nov.

General coloration black; head gray; halteres with yellow knobs; legs brown, conspicuously hairy; wings strongly tinged with blackish, streaked longitudinally with pale; cell 2d A narrow; male hypopygium with the dististyle a simple curved blade, the tip acute.

Male.—Length, about 3.8 millimeters; wing, 4.5.

Rostrum and palpi dark brown. Antennæ black throughout; second scapal segment oval; flagellar segments gradually decreasing in size outwardly; verticils elongate. Head dull gray, the orbits paler.

Pronotum black. Mesonotum black, the very restricted anterior and posterior lateral pretergites, together with the humeral region of the præscutum yellow; scutellum orange, the base blackened medially. Pleura black. Halteres black, the knobs and extreme base of stem yellow. Legs with the coxæ black; trochanters brownish yellow; femora and tibiæ brown, the tips darker; tarsi more blackened; segments of legs with very long conspicuous erect setæ. Wings (Plate 1, fig. 19)

strongly tinged with blackish, the elongate stigmal region slightly darker; pale longitudinal streaks in costal region, and along veins M, M_{3+4}, and 1st A; veins dark brown. Macrotrichia of veins long and conspicuous. Venation: Sc_1 ending opposite fork of Rs, Sc_2 some distance from tip of Sc_1; cell 2d A narrow.

Abdomen dark brown, the hypopygium blackened, the dististyles yellow. Male hypopygium (Plate 3, fig. 42) with the dististyle, *d*, a curved blade that terminates in an acute point, the distal half with numerous small setæ. What may be a tergal structure appears as two pale truncated cushions, densely set with short setulæ, each lobe with a single longer bristle. There is a possibility that these structures are really gonapophyses, but if so they are very different from those of other allied species.

Habitat.—Formosa (south).

Holotype, male, Keinensan, near Heito, altitude 5,000 feet, March 13, 1929 (*S. Issiki*).

Cryptolabis trichopoda is very distinct from *C. aliena* (Alexander), the only other Formosan species of the genus. In general appearance it is more like the Indian *C. funebris* (Alexander), differing conspicuously in the structure of the dististyles of the male hypopygium.

ERIOPTERA (EMPEDA) SULFUREOCLAVATA sp. nov.

General coloration gray; scapal segments of antennæ black; legs light brown; halteres with conspicuous sulphur yellow knobs; wings gray, the stigmal region scarcely darker; Sc long; anal veins strongly divergent; male hypopygium with the dististyles unblackened.

Male.—Length, about 2.8 millimeters; wing, 3.5.

Rostrum gray; palpi black. Antennæ with the scapal segments black, the flagellum pale brownish yellow, the outer segments darker. Head light gray.

Mesonotum dark brownish gray, the lateral pretergites light sulphur yellow, the posterior sclerites of notum clearer gray. Pleura dark gray, the dorsopleural region pale yellowish white. Halteres pale, the knobs light sulphur yellow. Legs with the fore coxæ dark brown, the remaining coxæ and trochanters brownish yellow; remainder of legs light brown, the terminal tarsal segments darker. Wings (Plate 1, fig. 20) broad, iridescent gray, the prearcular and costal portions more yellowish;

stigma scarcely darker; veins pale brown, those in the costal region more yellowish. Macrotrichia of veins relatively short. Venation: Sc long, Sc_1 ending beyond midlength of Rs, Sc_2 a short distance from its tip; R_3 of moderate length, longer than R_{3+4}; m-cu at fork of M; vein 2d A short and nearly straight, the anal veins strongly divergent; cell 1st A very wide at margin.

Abdomen dark brown, the incisures narrowly pale; hypopygium yellow. Male hypopygium (Plate 3, fig. 43) with the outer lobe of basistyle, *b*, terminating in two or three very long setæ; inner lobe stouter, densely set with erect setæ. Dististyles both broad, not blackened, the outer style bifid.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 14, 1929 (*ex Parish*).

Erioptera (*Empeda*) *sulfureoclavata* is readily separated from all regional species with long subcosta by the coloration, as the conspicuous sulphur yellow knobs of the halteres, and the venation, as the length and course of vein R_3 and the strong divergence of the anal veins.

ERIOPTERA (EMPEDA) LILIPUTINA sp. nov.

Size very small (wing, male, 2.6 millimeters); general coloration grayish black; halteres dusky, the knobs obscure yellow; legs black; wings strongly suffused with blackish; Sc long; cell 1st M_2 closed.

Male.—Length, about 2 millimeters; wing, 2.6.

Rostrum and palpi brownish black. Antennæ black throughout. Head dark brownish gray.

Pronotum brownish black. Anterior lateral pretergites very restrictedly obscure yellow. Mesonotum dull grayish black, the pseudosutural foveæ and tuberculate pits more intense black; scutellum somewhat more pruinose. Pleura grayish black. Halteres dusky, the knobs obscure yellow. Legs with the coxæ blackish; trochanters brownish yellow; remainder of legs brownish black. Wings (Plate 1, fig. 21) with a strong blackish suffusion, the veins darker. Venation: Sc long, Sc_1 extending to beyond one-third the length of Rs, Sc_2 a short distance from its tip; Rs relatively long and straight; vein R_3 straight, the cell thus pointed at base; cell 1st M_2 closed; m-cu erect, placed just beyond the fork of M.

Abdomen black, including the hypopygium. Male hypopygium with the outer dististyle blackened, the dististyle bifid, the outer arm densely covered with microscopic setulæ. Inner

dististyle a straight slender rod, the apex obtuse. Gonapophyses appearing as pale flattened blades.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 3,600 feet, August 29, 1929 (*S. Issiki*).

Erioptera (*Empeda*) *liliputina* is readily told from all described regional species by the small size and venation, notably the closed cell 1st M_2.

ORMOSIA ANTHRACOPODA sp. nov.

General coloration gray; halteres yellow; legs black; wings cream-colored, with a sparse brown pattern; male hypopygium with the apex of the basistyle produced into a small spine.

Male.—Length, about 6 millimeters; wing, 7.

Rostrum and palpi black. Antennæ black throughout, of moderate length; verticils of the basal flagellar segments long, becoming shorter on the outer segments. Head gray.

Mesonotal præscutum light gray with four darker brownish gray stripes that are inconspicuous against the ground color; pseudosutural foveæ and tuberculate pits black; scutal lobes brownish gray; scutellum and postnotum clearer gray. Pleura clear gray. Halteres yellow. Legs with the coxæ and trochanters brownish yellow; remainder of legs black. Wings (Plate 1, fig. 22) cream-colored, with a slight brownish tinge; stigma brown; restricted darker brown clouds at origin of Rs, Sc_2, along cord, m, and tips of most longitudinal veins; relatively inconspicuous whitish areas before and beyond the stigma; veins brown, darker in the clouded areas. Venation: Sc_1 ending opposit R_2; Sc_2 about opposite one-fifth the length of Rs; R_2 just beyond the fork of R_{2+3+4}; tips of veins R_3 and R_4 deflected cephalad; point of union of distal section of M_3 with m angulated and weakly spurred; m-cu shortly before fork of M; vein 2d A sinuous on distal half.

Abdomen brownish gray, the hypopygium dark. Male hypopygium (Plate 3, fig. 44) with the tip of the basistyle, *b*, produced into a small acute spine. Two dististyles, one a strongly curved sickle-shaped spine, extended into a long straight blackened point, the margin with very long erect setæ; second dististyle nearly straight, the basal half more dilated. Gonapophyses small, in general outline nearly like the inner dististyle, the apical spine more acute.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 6,500 to 7,800 feet, October 26, 1929 (*S. Issiki*).

Ormosia anthracopoda is very distinct from the other species of the genus described from Formosa. It belongs to the *aculeata* group, having the apex of the basistyle of the male hypopygium produced into an acute spine.

STYRINGOMYIA TAIWANENSIS sp. nov.

General coloration pale yellow; legs uniformly yellow or with scarcely indicated pale brown bands on femora; wings yellow, the veins along cord and outer ends of cell 1st M_2 a little darker; vein 2d A gently curved to the margin; male hypopygium with three apical spines on basistyle, one more isolated and terminating in an obtuse knob that is further abruptly narrowed into a hairlike spine.

Male.—Length, about 7 millimeters; wing, 5 to 5.5.

Female.—Length, about 5 to 5.5 millimeters; wing, 5 to 5.4.

Rostrum yellow; palpi alternately yellow and dark brown. Antennal flagellum pale yellow, the scapal segments scarcely darker. Head light sulphur yellow.

Pronotum sulphur yellow. Mesonotum more testaceous yellow, without dark markings. Pleura testaceous yellow. Halteres pale, the knobs light yellow. Legs uniformly yellow, in cases the femora with scarcely indicated pale brown bands; terminal tarsal segments black. Wings (Plate 1, fig. 23) yellow, with a sparse brown clouding along the cord and outer end of cell 1st M_2, most evident on r-m; veins yellow, darker in the infuscated areas. Venation: Vein 2d A curved gently to the margin.

Abdomen yellow, the caudal margins of the intermediate tergites narrowly dark brown. Male hypopygium (Plate 3, fig. 45) with the ninth sternite, *9s*, broad, the apical spines widely separated. Basistyle terminating in three conspicuous spines, two being long and extended into acute points, the third arising from a separate apical lobe of the basistyle, knobbed at apex, thence further produced into a hairlike point. Dististyle, *d*, complicated in structure, the long slender outer arm bearing a very elongate subterminal seta; margin of arm near base with a series of peglike spines. Spines of intermediate arms of dististyle unusually long and slender.

Habitat.—Formosa.

Holotype, male, Hassensan, altitude 3,500 feet, October 21, 1929 (*S. Issiki*). Allotopotype, female, in copula with the type.

Paratopotypes, 6 males and females, altitude 2,500 to 5,500 feet, October 22 to 25, 1929 (*S. Issiki*); paratype, 1 female, Funkiko, April 21, 1917 (*T. Shiraki*).

Styringomyia taiwanensis has been confused with *flava* Brunetti and the paratype was earlier recorded as being that species.[7] The present form differs in the coloration of the wings and details of structure of the male hypopygium.

STYRINGOMYIA SINENSIS sp. nov.

General coloration yellow, the mesonotum largely black, more or less variegated with pale at the suture; halteres yellow; femora and tibiæ with narrow brownish black rings; wings yellow, with a sparse dark pattern, including the vicinity of r-m, outer end of cell 1st M_2 and end of vein 2d A; small dark marginal spots at ends of medial and cubital veins; vein 2d A strongly angulated and weakly spurred at margin; male hypopygium with the dististyle very large and complex, four-lobed, the two intermediate lobes with combs of spines.

Male.—Length, about 7 to 8 millimeters; wing, 5.2 to 6.

Female.—Length, about 6 to 6.5 millimeters; wing, 4.6 to 5.

Antennæ with the scape black; flagellum yellow. Head chiefly ocherous; a dark spot touching inner margin of eye at narrowest point of vertex.

Mesonotum extensively to almost entirely blackened, more or less pruinose, in certain of the specimens brightened at the suture; the amount of pale coloring variable, in some specimens involving the posterior third of the præscutum and the scutal lobes, the anterior portion of præscutum always blackened. Pleura abruptly and uniformly yellow. Halteres pale, the knobs bright yellow. Legs with the coxæ and trochanters yellow; femora yellow, with two narrow dark rings that are interrupted beneath; tibiæ yellow, the tips narrowly blackened, with a narrower ring at just before midlength, this obsolete on lower surface; tarsi yellow, the tips of tarsal segments one and two darkened; terminal segment dark brown. Wings (Plate 1, fig. 24) yellow, the veins a little darker yellow; a restricted dark pattern, arranged as follows: At r-m, involving the ends of all surrounding veins; outer end of cell 1st M_2; on m-cu and its junction with Cu_1; tip of 2d A; small darkened marginal areas at ends of veins R_5 to Cu_1, inclusive. Venation: 2d A angularly

[7] Ann. Ent. Soc. America 13 (1920) 253.

bent into the margin, this curvature rectangular or acute, usually with a short spur at the bend.

Abdomen yellow, the tergites with geminate brown spots at caudal margin, with vague indications of paler brown markings on the basal ring; on segment seven with a median brown stripe; hypopygium pale. Male hypopygium (Plate 3, fig. 46) with the dististyle, *d*, four-lobed, the outer lobe long and slender, bearing the usual very long apical seta; second arm bilobed at apex, the margin with groups of long black spines to produce a comblike appearance; third lobe flattened, with a $\frown$-shaped series of shorter peglike spines; innermost lobe bearing an apical series of very long setoid spines. Ninth sternite, 9*s*, slender, with two apical setæ that are placed close together. Ninth tergite without lateral shoulders, as found in *mahensis*.

Habitat.—Western China and Formosa.

Holotype, male, Mount Omei, Szechwan, China, altitude 4,500 feet, August 4, 1929 (*ex Parish*). Allotopotype, female. Paratopotypes, 15 males and females, August 2 to 19, 1929; paratypes, 8 males and females, Hassensan, Formosa, altitude 2,500 to 3,500 feet, October 21 to 25, 1929 (*S. Issiki*).

By Edwards's key to the species of *Styringomyia* [8] the present fly runs to *S. mahensis* Edwards, an otherwise very different fly. The structure of the male hypopygium separates *S. sinensis* from all regional forms.

[8] Trans. Ent. Soc. London (1914) 210–212.

ILLUSTRATIONS

[Legend; *a*, ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Limonia* (*Discobola*) *taivanella* sp. nov., venation.
2. *Limonia* (*Limonia*) *koxinga* sp. nov., venation.
3. *Limonia* (*Libnotes*) *hassenana* sp. nov., venation.
4. *Limonia* (*Rhipidia*) *triarmata* sp. nov., venation.
5. *Limonia* (*Dicranomyia*) *subpunctulata* sp. nov., venation.
6. *Limonia* (*Geranomyia*) *apicifasciata* sp. nov., venation.
7. *Antocha* (*Antocha*) *styx* sp. nov., venation.
8. *Helius* (*Eurhamphidia*) *perelegans* sp. nov., venation.
9. *Dicranoptycha issikina* sp. nov., venation.
10. *Dicranota* (*Amalopina*) *delectata* sp. nov., venation.
11. *Adelphomyia issikina* sp. nov., venation.
12. *Limnophila* (*Prionolabis*) *serridentata* sp. nov., venation.
13. *Trentepohlia* (*Mongoma*) *montina* sp. nov., venation.
14. *Gonomyia* (*Progonomyia*) *confluenta* Alexander, venation.
15. *Gonomyia* (*Gonomyia*) *nansei* sp. nov., venation.
16. *Gonomyia* (*Lipophleps*) *sauteri* sp. nov., venation.
17. *Gonomyia* (*Lipophleps*) *neonebulosa* sp. nov., venation.
18. *Gonomyia* (*Lipophleps*) *sinuosa* sp. nov., venation.
19. *Cryptolabis* (*Baeoura*) *trichopoda* sp. nov., venation.
20. *Erioptera* (*Empeda*) *sulfureoclavata* sp. nov., venation.
21. *Erioptera* (*Empeda*) *liliputina* sp. nov., venation.
22. *Ormosia anthracopoda* sp. nov., venation.
23. *Styringomyia taiwanensis* sp. nov., venation.
24. *Styringomyia sinensis* sp. nov., venation.

PLATE 2

FIG. 25. *Dolichopeza* (*Nesopeza*) *tarsalba* sp. nov., male hypopygium, lateral.
26. *Dolichopeza* (*Nesopeza*) *tarsalba* sp. nov., male hypopygium, ninth tergite.
27. *Dolichopeza* (*Nesopeza*) *tarsalba* sp. nov., male hypopygium, gonapophysis.
28. *Dolichopeza* (*Nesopeza*) *tarsalba* sp. nov., male hypopygium, eighth sternite.
29. *Dolichopeza* (*Oropeza*) *saitamensis* sp. nov., male hypopygium, ninth tergite.
30. *Dolichopeza* (*Oropeza*) *saitamensis* sp. nov., male hypopygium, inner dististyle.

FIG. 31. *Limonia* (*Discobola*) *taivanella* sp. nov., male hypopygium.
32. *Limonia* (*Limonia*) *koxinga* sp. nov., male hypopygium.
33. *Limonia* (*Rhipidia*) *triarmata* sp. nov., male hypopygium.
34. *Limonia* (*Dicranomyia*) *subpunctulata* sp. nov., male hypopygium.
35. *Limonia* (*Geranomyia*) *apicifasciata* sp. nov., male hypopygium.
36. *Antocha* (*Antocha*) *styx* sp. nov., male hypopygium.
37. *Dicranoptycha issikina* sp. nov., male hypopygium.

PLATE 3

FIG. 38. *Limnophila* (*Prionolabis*) *serridentata* sp. nov., male hypopygium.
39. *Gonomyia* (*Progonomyia*) *confluenta* (Alexander), male hypopygium.
40. *Gonomyia* (*Gonomyia*) *nansei* sp. nov., male hypopygium.
41. *Gonomyia* (*Lipophleps*) *sauteri* sp. nov., male hypopygium.
42. *Cryptolabis* (*Baeoura*) *trichopoda* sp. nov., male hypopygium.
43. *Erioptera* (*Empeda*) *sulfureoclavata* sp. nov., male hypopygium.
44. *Ormosia anthracopoda* sp. nov., male hypopygium.
45. *Styringomyia taiwanensis* sp. nov., male hypopygium.
46. *Styringomyia sinensis* sp. nov., male hypopygium.

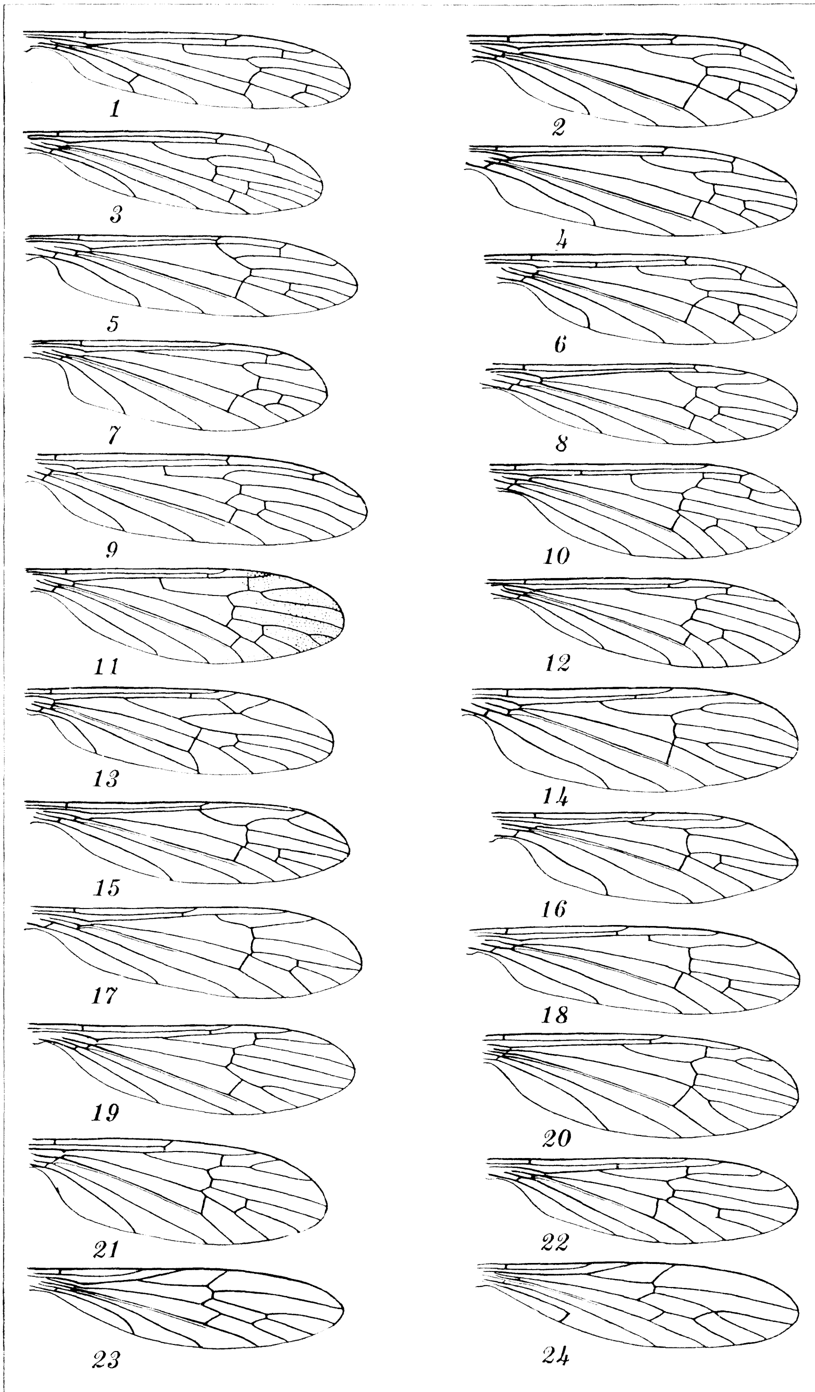

PLATE 1.

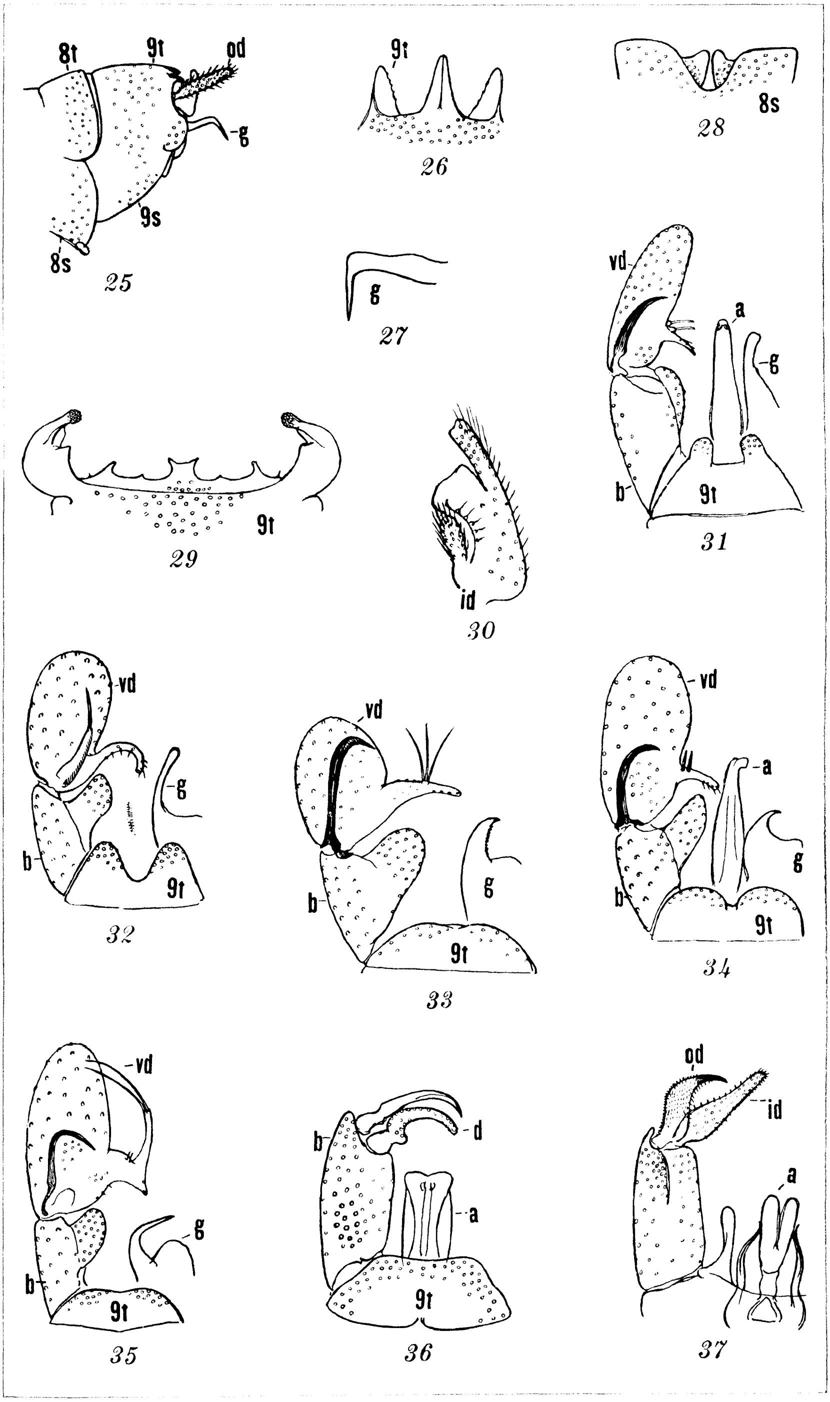
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PLATE 2.

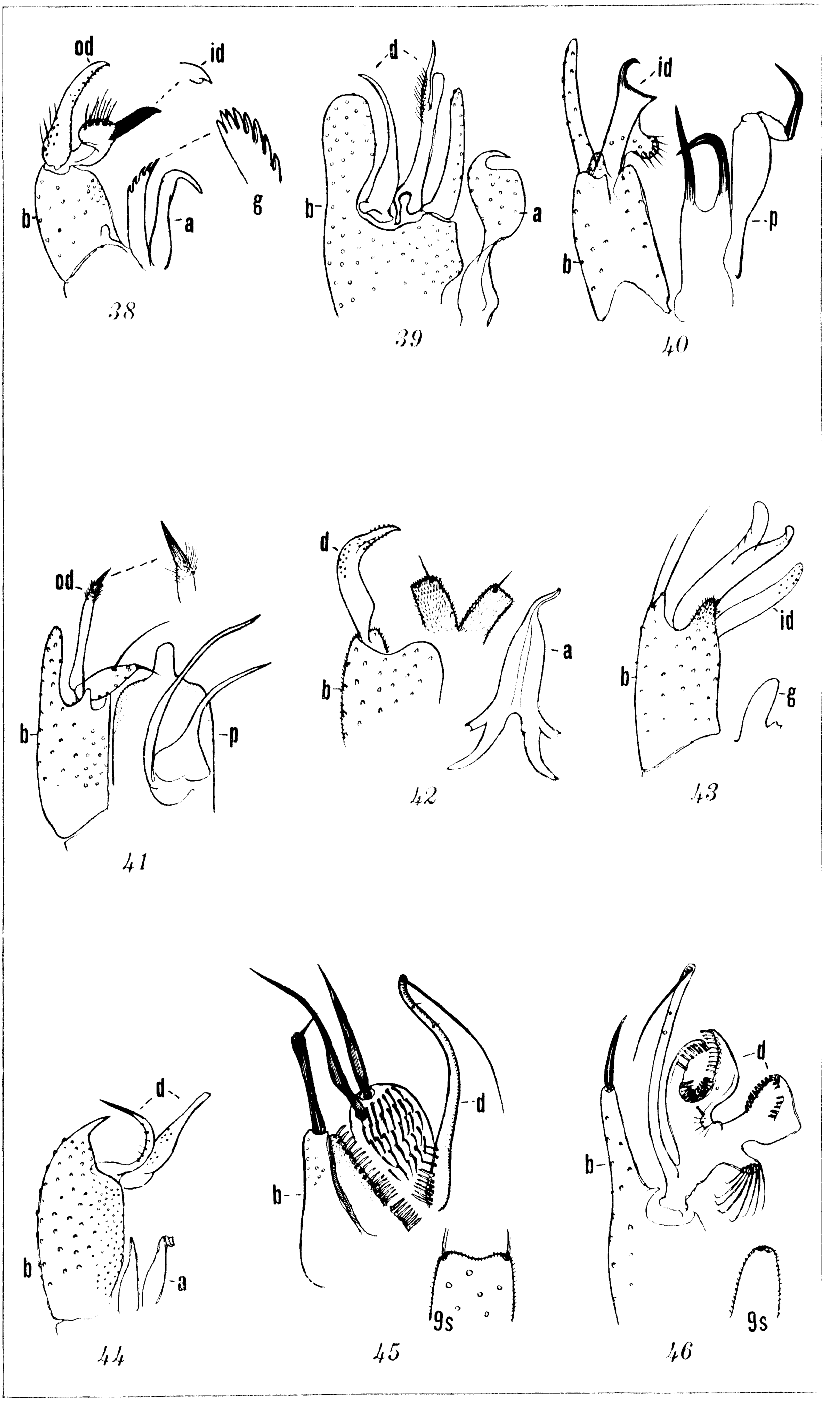
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PLATE 3.

SIXTH REPORT UPON DIPTERA PUPIPARA FROM THE PHILIPPINE ISLANDS

By G. F. Ferris

Of Stanford University, California

SEVEN TEXT FIGURES

For the material upon which this sixth report is based, I am as before indebted chiefly to Mr. R. C. McGregor. It has been my desire to present in these papers something approaching a review of the genera of the Hippoboscidæ, at least as far as this family is represented in the Philippine Islands. Because of this, there is a departure in the present report from the procedure followed in the earlier papers of the series. Certain species that are not at present known from the Philippine Islands, but which may reasonably be assumed to occur there, are here included. That these species will eventually be collected in the Islands is certain, and their inclusion herein permits at least some discussion of probably all the genera of the Hippoboscidæ that occur in the Philippines, with the exception of *Stenopteryx*. This genus is known from Europe and India, where it occurs on swallows, and is to be looked for on these birds elsewhere.

Genus HIPPOBOSCA Linnæus

This genus, the type of the Hippoboscidæ, may be characterized as follows: Hippoboscidæ with functional, noncaducous wings in which there are several veins behind the costa; with but two "cross veins" and consequently without an anal cell; with the wing membrane showing a series of slight, radiating furrows and ridges in the nonveined portion. Claws simple. Antennæ almost entirely concealed within their pits. Prothorax with a distinct, more or less sclerotic, pronotal plate, the humeral processes of the mesothorax lacking, the head consequently appearing as relatively free from the thorax and not received into its anterior border as in most members of the family. Ocelli lacking. Abdomen with the derm somewhat squamose-reticulate, but without a distinct median, dorsal area of transverse striations.

Type of the genus, *Hippobosca equina* Linnæus.

Notes.—This genus, as the type of the Hippoboscidæ, stands in need of a thorough comparative morphological study. It is not my intention to attempt such a study in connection with the present paper, but certain morphological features which are of systematic importance within the family are here dealt with on the basis of the two species *H. equina* Linnæus and *H. maculata* Leach, the former being the type of the genus. Neither of these species appears to have been recorded from the Philippine Islands, although they surely are to be found there.

The species of this genus are among the most striking members of the family, owing to the coloration of the thoracic dorsum. Very little consideration has been given by earlier authors to the morphology of the group and specific differentiation has been based chiefly upon these colors, with the result that there are probably several more names than there are species. Six alleged species are at hand, but this is not the place for a discussion of them.

In some respects this genus appears to be rather isolated from the remainder of the family, so much so that Speiser has placed it as the sole member of the subfamily Hippoboscinæ. I am not myself so much impressed by its peculiar features and am inclined to regard it as definitely a member of the group of mammal-infesting genera including certainly *Lipoptena, Echestypus, Melophagus,* and probably *Ortholfersia* and *Allobosca.*

The palpi in *Hippobosca* (fig. 4, *b*) are well developed and are strongly deflected. The clypeal region (fig. 4, *b*) is quite deeply emarginate. The antennæ are short and almost concealed within the open antennal pits, the second segment more or less globular (fig. 4, *e*) and containing the invaginated third segment from which rises the antleriform arista; the first segment is not recognizable.

The head is somewhat less flattened than in most of the Hippoboscidæ and is without a sharp, thin, occipital epiphysis. The prothorax presents a very definite pronotal plate, in contrast to all the other Hippoboscidæ in which this region is membranous, and in *H. maculata* and similar species this bears a transverse row of setæ. The humeral processes are entirely lacking. The remainder of the thorax (fig. 3) presents no unusual features except the pronounced development of the swollen pleurotergites. The claws (fig. 4, *h*) are simple, with large, flat pulvilli and a stout, setiform empodium.

The wings (fig. 2) have as their chief peculiarity the development of a series of ridges and furrows radiating from the veins to the posterior margin. Structurally these are indicated only by more or less faint lines of pigmentation. The wings are entirely devoid of minute setulæ.

The abdomen is more or less thickly beset with setæ of various sizes, each borne upon a small, sclerotic ring. In a few forms these rings are present but in part seem to bear no setæ. The remainder of the derm is for the most part marked with a mosaic of small sclerotic or pigmented scalelike markings, but there is no such dorsal area of transverse striations as appears in the Olfersiinæ. There is the usual large tergal and small sternal basal plate. In *H. equina* there are three additional, small tergal plates and in all available material there are two pairs of large and heavily sclerotic, swollen, subapical plates, except in the male of *H. equina* which has but one such pair. There is but comparatively little sexual dimorphism. The claspers of the male are very small, and the genital and anal openings tend to be more or less strongly retracted to the ventral side of the body. In the male of *H. equina* the tergal plates are larger than in the female.

I have not attempted to work out the details of the copulatory apparatus of the male.

HIPPOBOSCA EQUINA Linnæus. Figs. 1; 2, a; 3; 4, a, b, d–h.

AUSTEN, Ann. & Mag. Nat. Hist. VII 12 (1903) 256.

MASSONAT, Ann. de l'Univ. de Lyon (nouvelle série) 1 Fasc. 28 (1909) 235–243, pl. 1, figs. 1–5.

STEKHOVEN, Die Bloedzuigende Arthropoda van Nederl. Oost Indie 1–2 (1923) 83–92; figs.

Material examined.—Several individuals from northern Africa and from Java, received through the kindness of the late Dr. M. Bezzi and Dr. J. H. Schuurmans Stekhoven.

Notes.—This species is apparently very common in Europe and northern Africa, and since it has been recorded from Burma, Java, and New Caledonia its presence in the Philippine Islands may be taken for granted, even in the absence of definite records. Its typical host is considered to be the domestic horse, although Massonat has recorded it from cattle, dromedary, dog, and even birds.

I would at this point call attention to the very close resemblance between this species and the supposedly distinct *H. capensis* von Olfers (=*H. francilloni* Leach and *H. canina*

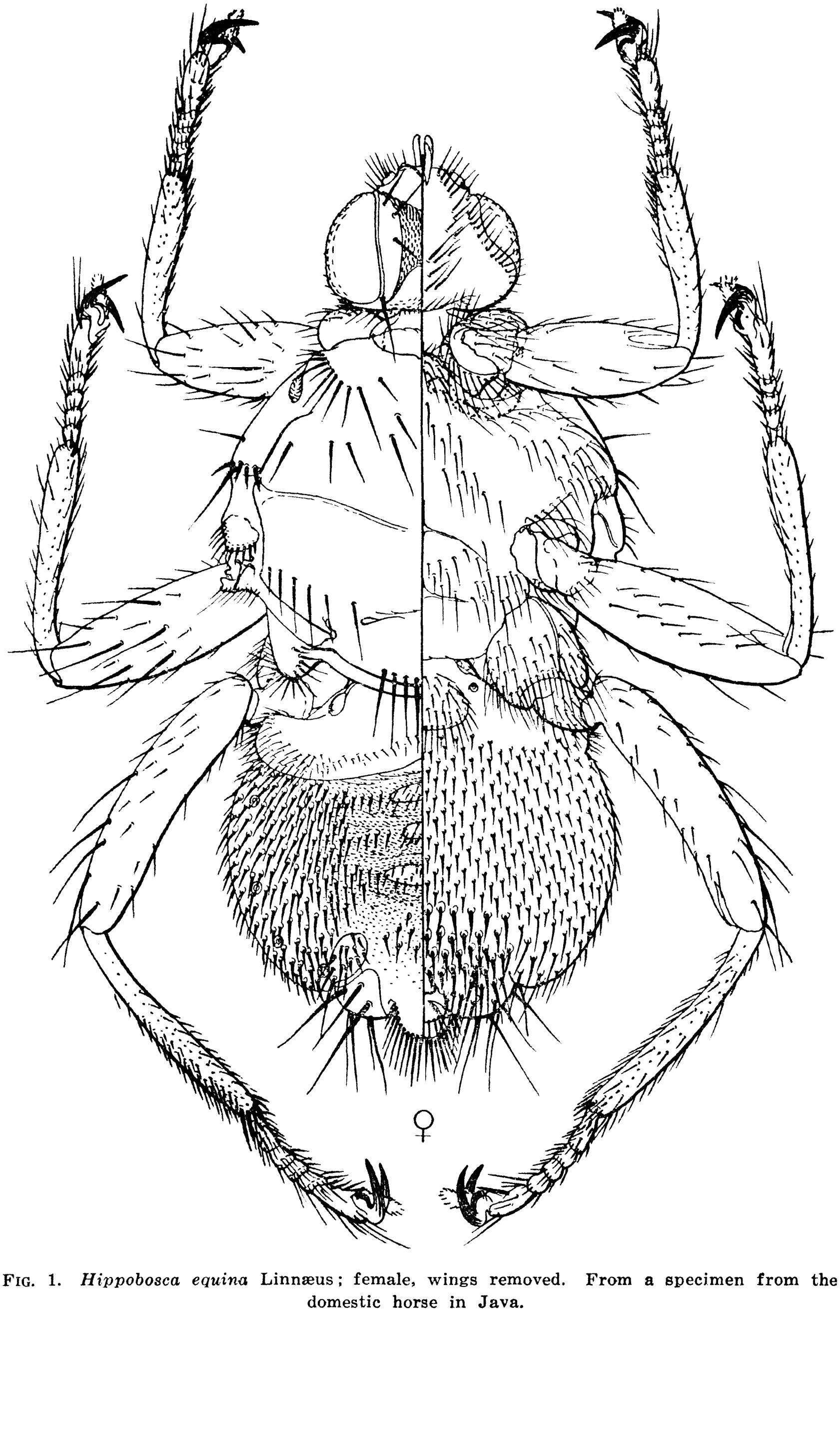

FIG. 1. *Hippobosca equina* Linnæus; female, wings removed. From a specimen from the domestic horse in Java.

Rondani), which occurs commonly on dogs in Africa and apparently almost throughout Asia. I have at hand specimens of this, determined by Bezzi as *H. capensis,* from northern Africa and other specimens from China from dogs. Austen has called attention to the fact that the color differences supposed to differentiate these two species do not hold and has indicated that they may be separated only by the color of the wing veins, typical *H. capensis* having the veins pale except for their noticeably dark apices, while *H. equina* has the veins uniformly colored.

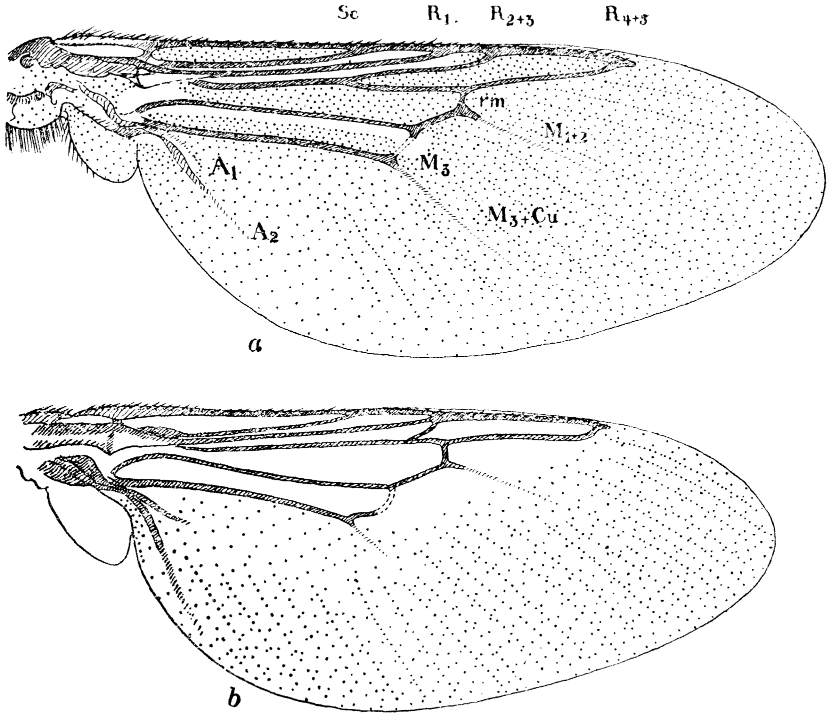

FIG 2. *Hippobosca equina* Linnæus; *a*, wing. *Hippobosca maculata* Leach; *b*, wing. The figures are drawn to slightly different scales.

Structurally there appears to be no difference whatsoever between these two supposed species. There is a considerable degree of variation in the form and size of the setæ of the abdomen, but this does not appear to correlate with the kind of host and may be regarded as individual. An examination of more material is desirable, but it is my personal belief that the two species are the same thing.

As the species is the type of its genus and, consequently, of the Hippoboscidæ, I shall here consider it at some length. The

color pattern has been described by many authors and is figured by Stekhoven and will here be passed over. The species is one of the smaller members of its genus, reaching a length of not more than 10 millimeters in the most fully expanded females, with a wing length of 6 millimeters, while *H. camelina* reaches a total length of 12 millimeters with a wing length of 9 millimeters.

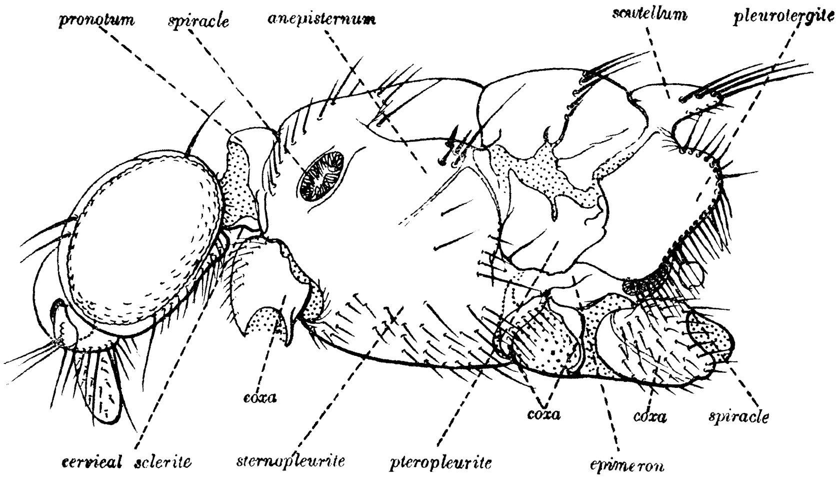

FIG. 3. *Hippobosca equina* Linnæus; lateral aspect of head and thorax.

The body (fig. 1) is rather noticeably hairy, the hairs for the most part being pale. There is a considerable actual variation in size and shape of the abdominal setæ, and an apparent variation in their distribution due to changes in the size and shape of the abdomen.

The palpi are short and broad and strongly deflexed. The clypeus (fig. 4, *b*) is distinctly emarginate. The antennæ are short, retracted into deep pits, with the first segment not distinguishable and with the second (fig. 4, *d*) more or less globular and enveloping the small third segment (fig. 4, *f*) from which rises the branched arista. The head as a whole is rather quadrate in form.

The pronotum is developed as a distinct plate, which does not, however, bear a transverse row of setæ as in *H. maculata* and some other species. The humeral processes of the mesothorax are entirely lacking. The scutellum is small and rounded and the pleurotergites quite strongly swollen. In fig. 3 is shown the lateral aspect of the thorax and head, with the parts interpreted in accord with the views of recent students of the

Diptera. The legs present nothing unusual; the claw is shown in fig. 4, *h*.

The wing (fig. 2, *a*) shows in slide preparations but little evidence of the ridges and furrows that appear in dry specimens, these being indicated only by faint lines of pigmentation.

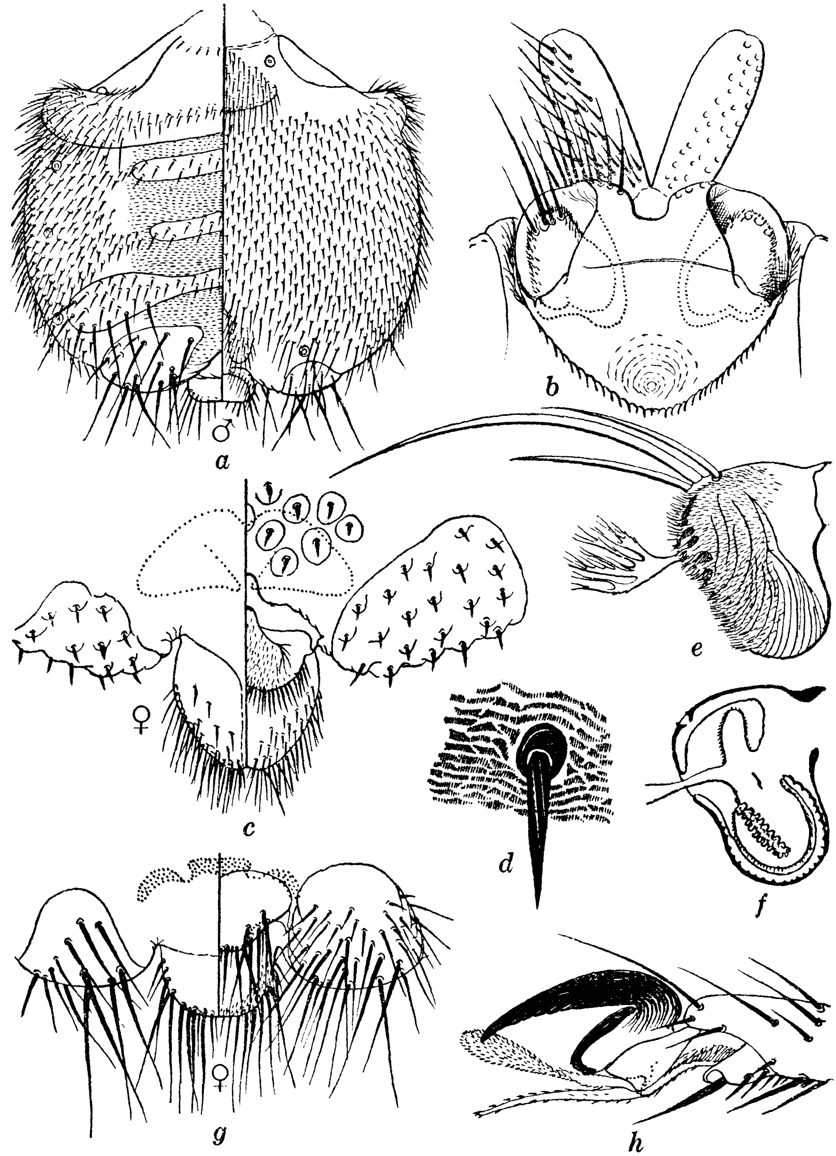

FIG. 4. *Hippobosca equina* Linnæus; *a*, abdomen of male; *b*, anterior portion of head; *d*, seta and markings of derm of abdomen; *e*, lateral aspect of antenna as dissected from its pit; *f*, optical section of antenna; *g*, apex of abdomen of female; *h*, claw. *Hippobosca maculata* Leach; *c*, apex of abdomen of female.

The venation is indicated in the figure in accord with the commonly accepted Comstock-Needham system. It should be noted that the vein R_{2+3} is almost parallel to the vein R_1. The wing membrane is pigmented throughout except for a distinct hyaline furrow along the medial stem and for the cells sc and R_1. There are no setulæ, and the costal border is beset with short stout setæ, with no long hairs.

The abdomen shows the usual large basal tergite. Following it are three small plates and close to the apex two pairs of large, swollen plates bearing long setæ (fig. 4, *g*). The apical lobe of the abdomen is broadly rounded and does not possess a median pale stripe. The ventral side of the abdomen bears only a small basal plate. The setæ of the abdomen are variable in size and each arises from a small, sclerotic base. The derm is marked with minute, sclerotic and pigmented, squamose-reticulate areas (fig. 4, *d*), especially prominent in the median dorsal region of specimens that are not fully expanded, but there is little or no development of such an area of transverse striations as appears in the Olfersiinæ.

The male is very similar to the female, except that the dorsal plates of the abdomen (fig. 4, *a*) are conspicuously larger and the apical pair of marginal plates is lacking. The claspers are very small.

HIPPOBOSCA MACULATA Leach. Figs. 2, b; 4, c; 5.

STEKHOVEN, Die Bloedzuigende Arthropoda van Nederl Oost Indie 1–2 (1923) 1–82, figs.

Specimens examined.—Numerous individuals from Java, received through the kindness of Dr. J. H. Schuurmans Stekhoven.

Notes.—This species is characteristically a parasite of domestic cattle and has been recorded from Europe, Africa, southern Asia, and the East Indies. Its occurrence in the Philippine Islands is confidently to be expected.

The species is larger and darker in color than *H. equina,* but aside from these differences it is also very distinct structurally. It is one of a group of structurally very similar species that includes at least *H. camelina* Leach (= *H. dromedarina* Speiser) and *H. rufipes* von Olfers. The wing (fig. 2, *b*) is marked especially by the very short R_{2+3}, which appears almost as a crossvein and by the absence of pigmentation from the entire region occupied by the veins. The head (fig. 5) is more nearly circular than in *H. equina,* and the thorax much less hairy.

The scutellum is broad and almost truncate. The abdomen, except for the median dorsal region, is thickly beset with small setæ, each arising from a sclerotic ring. On the ventral side the setæ decrease in length toward the apex and the sclerotic bases become enlarged into rather large tubercles. There are no median tergal plates. The two pairs of subapical lateral plates are very large and prominent (fig. 4, *c*), the first pair being beset with long setæ and the second only by very short setæ. The apical lobe is of a characteristic form and is divided by a pale median furrow into two parts. The male is very similar to the female, lacking the median tergal plates of the abdomen and having the same subapical, lateral plates and apical lobe. However, the apex of the abdomen is retracted strongly to the ventral side of the body; the first pair of subapical plates is very large and the second pair appears only on the ventral side. The ventral side lacks the area of large tubercles that is seen in the female.

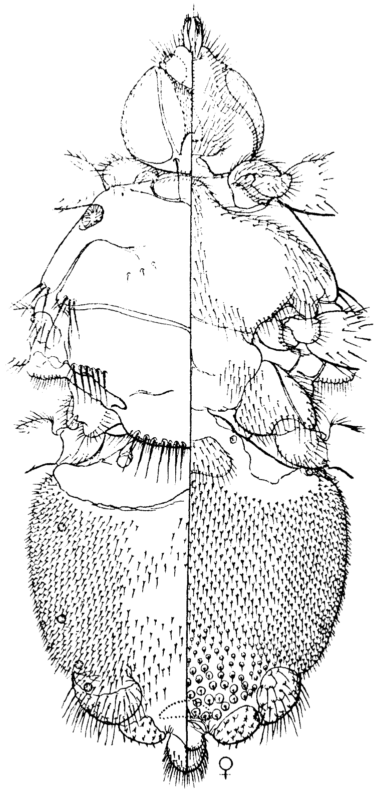

FIG. 5. *Hippobosca maculata* Leach; female, wings and legs removed. From a specimen from domestic cattle in Java.

Genus MELOPHAGUS Linnæus

Hippoboscidæ in which the forewings are represented only by a minute process and the halteres are entirely lacking, the thorax greatly reduced. Claws simple. Antennæ short, retracted into the antennal pits. Eyes reduced, ocelli lacking.

Type of the genus, *Melophagus ovinus* Linnæus.

Notes.—This genus represents the extreme of specialization by reduction of parts to be found in the Hippoboscidæ. I would regard it, however, as belonging to the subfamily Hippoboscinæ.

MELOPHAGUS OVINUS Linnæus.

FERRIS and COLE, Parasitology 14 (1922) 192, figs. 8 and 9.

Notes.—This species is a familiar parasite of sheep and must surely be present in the Philippine Islands. It need not be discussed further here.

Genus LIPOPTENA Nitzsch

FERRIS and COLE, Parasitology 14 (1922) 180.

Hippoboscidæ with the wings well developed and functional throughout an early period of adult life, but eventually caducous and represented in older specimens only by their bases; venation tending to be weak and simplified by the suppression of certain veins, the disappearance of the medial stem leaving a large median cell. Antennæ short, almost completely concealed within their pits. Eyes well developed, although somewhat reduced. Ocelli present. Claws simple. Abdomen without a distinct dorsal, median area of transverse striations.

Type of the genus, *Pediculus cervi* Linnæus.

Notes.—This genus is composed of about a dozen described species, all of which occur on ungulates of the families Cervidæ, Tragulidæ, and Bovidæ. As represented in collections, they are generally wingless with but the wing bases remaining. However, specimens are occasionally taken in flight. Such volant individuals are usually somewhat difficult to associate with their dealated forms; because, as they have not fed, the abdomen is always greatly contracted.

The genus has been discussed at some length by Ferris and Cole (loc. cit.), and the wing of one species has there been figured. The single specimen at hand from the Philippine Islands is winged and throws some additional light upon the character of the venation in these forms. In two species, *L. cervi* (Linnæus) and *L. subulata* Coquillet, the venation is so greatly reduced as somewhat to obscure the pattern, but in the Philippine specimen the venation is more strongly developed (fig. 7, *a*). Here veins R_1 and R_{2+3} are present, although faint, the principal vein being R_{4+5}. In all the species the medial stem is suppressed, but its position is indicated still by a furrow. The suppression of this stem causes the formation of a single large cell, the apex of which is closed by the radial-medial crossvein and the branches of media, the whole appearing as a single oblique crossvein. It is evident that the venation is not of so isolated a type as has been supposed.

I would regard the genus as a member of the Hippoboscinæ. Its nearest relative is *Echestypus*, from African ungulates, which differs chiefly in the absence of ocelli and in the much reduced palpi. In addition to the following species it is possible that one is to be found on goats in the Philippine Islands.

LIPOPTENA sp. Figs. 6 and 7, a.

Specimen examined.—A single volant female from Mount Maquiling, Laguna Province, Luzon (*C. F. Baker*). The hosts are in all probability deer of the genus *Rusa*.

Notes.—The extreme contraction of the abdomen in volant individuals makes it impossible to determine definitely the characteristics of this part of the body, while in most species the head and the thorax offer but little in the way of definite specific characters. Thus, while there are slight differences between the specimen at hand and the types of *L. traguli* Ferris and Cole (which is probably a synonym of *L. gracilis* Speiser) which lead to a belief that the two species are distinct, I hesitate to describe this species as new on the basis of this single specimen. However, I am here figuring the species in order to call attention to the presence of the genus in the Philippine Islands.

The specimen is somewhat larger than the types of *L. traguli*, its length being 4 millimeters and the wing 4 millimeters; the length of an expanded specimen of *L. traguli* is the same. There is an indication of the presence of at least one small abdominal tergal plate which is not present in *L. traguli*.

Genus CRATAERINA von Olfers

AUSTEN, Parasitology 18 (1926) 350.

Hippoboscidæ belonging to the Ornithomyiinæ, with the wings present but reduced in size, at the most but little exceeding the apex of the abdomen, although retaining the normal number of well-developed veins, and with the apical portion of the wing strongly narrowed.

Type of the genus, *Ornithomyia pallida* Latreille (= *Crataerina lonchoptera* von Olfers).

Notes.—The genera *Crataerina, Myiophthiria,* and *Brachypteromyia* have been recognized for the reception of species having reduced wings and all occurring on birds of the family Micropodidæ. I have elsewhere shown that *Brachypteromyia* cannot be maintained as distinct from *Myiophthiria*. I am further strongly inclined to the view that the latter genus should be merged with *Crataerina*. There can be no doubt that these

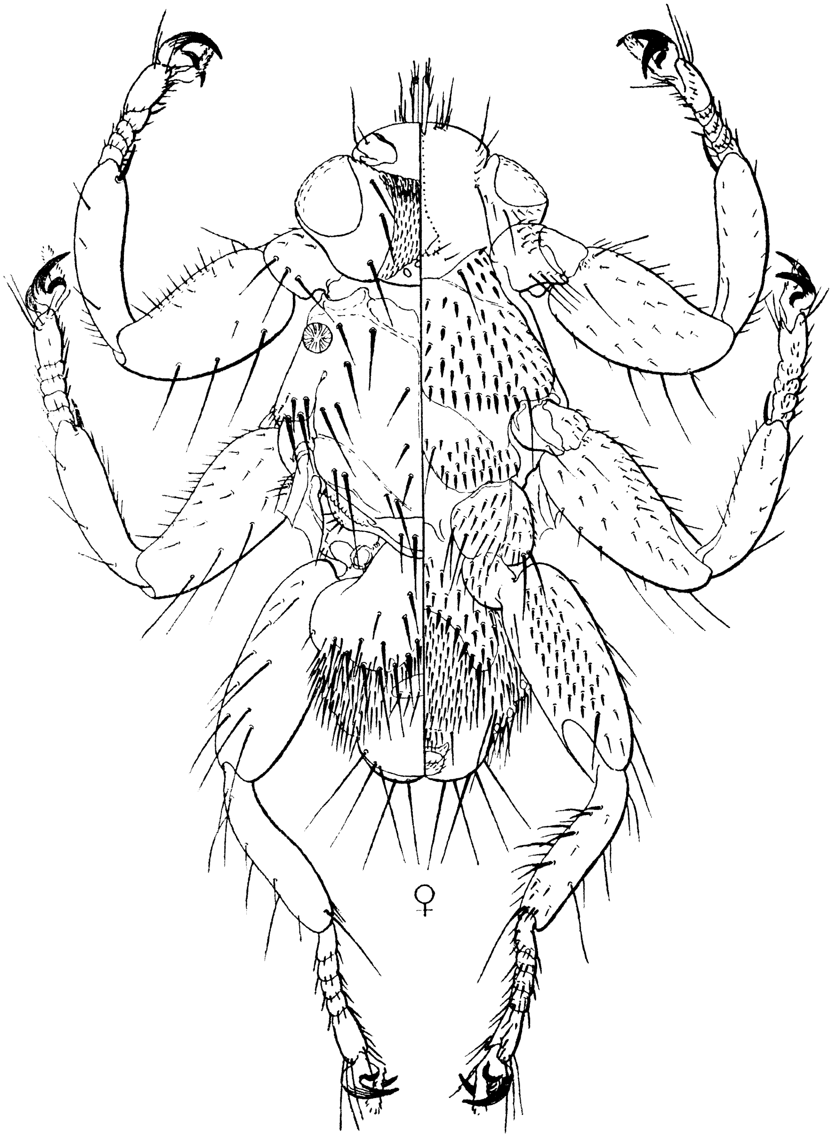

FIG. 6. *Lipoptena* sp.; female.

two so-called genera are members of a single stock of very closely related forms.

The only basis for a generic separation is to be found in the character of the wings. In *Myiophthiria* these are greatly re-

duced, not attaining even to the middle of the abdomen, and with the venation reduced to two or three longitudinal veins in addition to the strong costa. In *Crataerina*, on the other hand, the reduction of the wings is chiefly by way of a narrowing of the wing membrane; the veins, while somewhat reduced and much crowded, are still of about the usual number; the whole structure exceeds the tip of the abdomen. In one species, however, *C. obtusipennis* Austen, they are described as resembling the wings of *Myiophthiria* in form, although retaining the typical venation.

It seems evident that while there may be a technical basis for the recognition of two genera, all these species constitute a single series with *Myiophthiria* (= *Brachypteromyia*) *fimbriata* (Waterhouse), in which the wings are very small and the venation is reduced almost to a single vein, at one end, and *Crataerina longipennis* Austen, in which the wings are long and slender and the venation complete, at the other.

The question is merely one of what concept of the genus shall be adopted. I am inclined to accept the concept that calls for broader groups, but it would be well to examine certain apparently annectant forms, such as *Myiophthiria lygaeoides* and *Crataerina obtusipennis*, before definitely advocating the fusion of these two genera.

I have discussed the genus *Myiophthiria* in an earlier paper of this series. The single species here referred to *Crataerina* is not from the Philippine Islands, but closely related forms, or possibly even this species, must occur in these islands.

CRATAERINA ACUTIPENNIS Austen. Fig. 7, b.

AUSTEN, Parasitology (1926) 355, text fig. 1*a*.

Previous records.—From Madeira, Canary Islands, and South Africa, on various species of swifts.

Specimen examined.—A single female from "*Cypselus affinis*," Ceylon, received through the kindness of Mr. E. E. Green.

Notes.—A figure of this species would in most respects be merely a duplicate of the figure of *Myiophthiria reduvioides*, which has been presented in an earlier paper of this series. It is larger than the latter, pale in color, the legs are noticeably stouter, and it is perhaps somewhat more hairy, but otherwise there is little difference except for the wings, which slightly exceed the apex of the abdomen. The wing is shown in fig. 7, *b*.

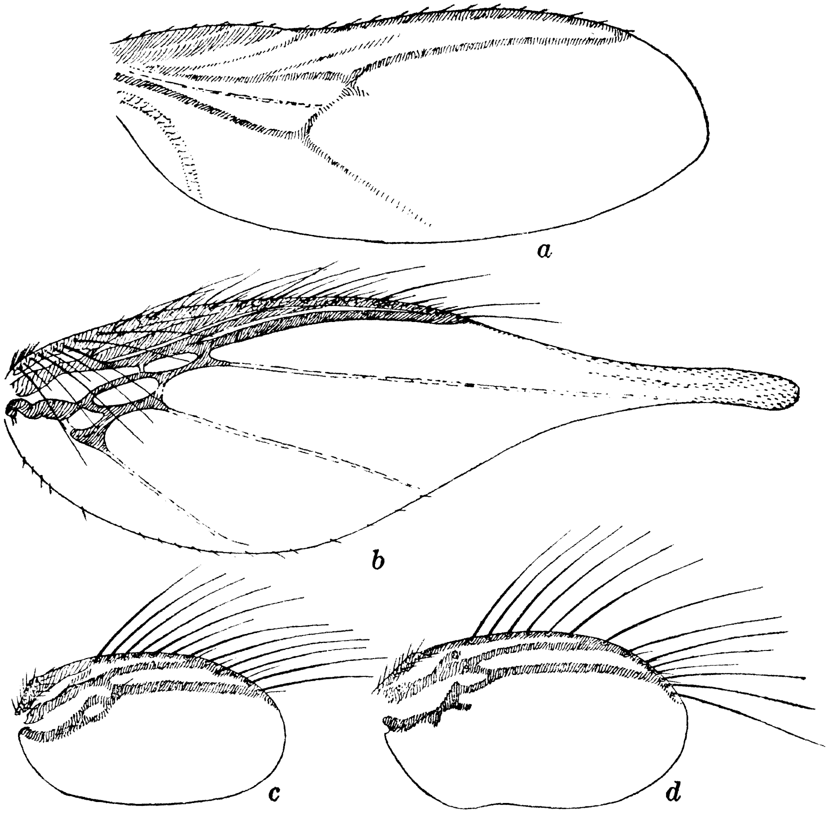

FIG. 7. *Lipoptena* sp.; *a*, wing. *Crataerina acutipennis* Austen; *b*, wing, from a specimen from Ceylon. *Myiophthiria reduvioides* Rondani; *c* and *d*, wings, from specimens from the Philippine Islands, showing variations.

Genus MYIOPHTHIRIA Rondani

MYIOPHTHIRIA REDUVIOIDES Rondani. Figs. 7, c and d.

FERRIS, Philip. Journ. Sci. **28** (1925) 377, fig. 5; **34** (1927) 218, fig. 9.

Additional records.—In addition to previous records, are the following: One male, host unknown, Badajos, Tablas Island (*F. Rivera*); and one female from *Geopelia striata* (Linnæus), Novaliches, Rizal Province, Luzon (*R. C. McGregor*).

Notes.—I may here call attention to the variation in the wings in specimens that I consider to represent this species. In fig. 7, *c*, is the wing of the specimen from Badajos and in fig. 7, *d*, that from Novaliches. These are drawn to the same scale and it may be noted that there is an evident variation in size as well as in the venation. Other specimens differ more or less from those here figured.

Genus ORNITHOICA Rondani

FERRIS, Canadian Entomologist 61 (1929) 280.

Certain errors for which I have been responsible in my previous treatment of this genus are pointed out in the reference cited above. Briefly, it may be said that owing to a failure properly to associate males and females the two sexes of a single species are recorded under different names. The corrections are noted below.

ORNITHOICA PUSILLA (Schiner).

Ornithoica promiscua Ferris and Cole, FERRIS, Philip. Journ. Sci. 28 (1925) 331–332.

Ornithoica pusilla (Schiner), FERRIS, Philip. Journ. Sci. 34 (1927) 207.

Ornithoica pusilla (Schiner), FERRIS, Canadian Entomologist 61 (1929) 28.

Additional records.—Females from *Pseudoptynx philippinensis* Kaup, Cavite Province, Luzon, July 30, 1928 (*R. C. McGregor*); and one male from *Loriculus bournsi* McGregor, Tablas Island, August 30, 1928 (*F. Rivera*).

Notes.—I have previously failed on the one hand properly to appreciate the specific differences between the American *Ornithoica confluenta* (Say) (= *O. promiscua* Ferris and Cole) and *O. pusilla* (Schiner) and on the other to associate male and female of the same species. I have consequently recorded females from the Philippine Islands as *O. promiscua* and their males as *O. pusilla*. That these males and females belong together seems clear, although even yet I have not seen specimens of the two sexes from the same host. The species may be accepted as *O. pusilla*.

Genus ORNITHEZA Speiser

ORNITHEZA METALLICA (Schiner).

FERRIS, Philip. Journ. Sci. 27 (1925) 419, figs. 4, 5; 34 (1927) 213, fig. 6.

Additional records.—A male from *Xantholæma roseum* (Dumont), and two females from *Loriculus bournsi* McGregor, Badajos, Tablas Island, August 29, 1928 (*F. Rivera*); a female from *Eurystomus orientalis* (Linnæus), Davao, Mindanao, March 27, 1927 (*F. Rivera*); a male from *Hemiprocne comata* (Temminck), Mayo, Mindanao, April 21, 1927 (*F. Rivera*).

Notes.—The specimen from *Eurystomus* differs from others in lacking the small dorsal plates of the abdomen, but their position is indicated by hairless areas.

Genus ORNITHOMYIA Latreille

ORNITHOMYIA AVICULARIA (Linnæus).

FERRIS, Philip. Journ. Sci. 34 (1927) 211, figs. 4 and 5.

Additional record.—A single female from *Pyrotrogon ardens* (Temminck), Mount Mayo, Davao, Mindanao, April 25, 1927 (*F. Rivera*).

Genus LYNCHIA Weyenbergh

LYNCHIA SARTA (Ferris).

Ornithoponus sartus FERRIS, Philip. Journ. Sci. 28 (1925) 333, figs. 3 and 4.

Additional record.—A single female from *Microhierax meridionalis* Grant, Mount Galintan, Davao, Mindanao, May 14, 1927 (*F. Rivera*).

LYNCHIA SETOSA Ferris.

FERRIS, Philip. Journ. Sci. 34 (1927) 227, figs. 14 and 15.

Additional records.—A male from *Circus* sp., Manila, February 14, 1927 (*R. C. McGregor*); and a male from *Ixobrychus astrologus* Wetmore, Obando, Bulacan Province, Luzon, December 16, 1927 (*R. C. McGregor*).

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Hippobosca equina* Linnæus; female, wings removed. From a specimen from the domestic horse in Java.

2. *Hippobosca equina* Linnæus; *a*, wing.
Hippobosca maculata Leach; *b*, wing. The figures are drawn to slightly different scales.

3. *Hippobosca equina* Linnæus; lateral aspect of head and thorax.

4. *Hippobosca equina* Linnæus; *a*, abdomen of male; *b*, anterior portion of head; *d*, seta and markings of derm of abdomen; *e*, lateral aspect of antenna as dissected from its pit; *f*, optical section of antenna; *g*, apex of abdomen of female; *h*, claw.
Hippobosca maculata Leach; *c*, apex of abdomen of female.

5. *Hippobosca maculata* Leach; female, wings and legs removed. From a specimen from domestic cattle in Java.

6. *Lipoptena* sp.; female.

7. *Lipoptena* sp.; *a*, wing.
Crataerina acutipennis Austen; *b*, wing, from a specimen from Ceylon.
Myiophthiria reduvioides Rondani; *c* and *d*, wings, from specimens from the Philippine Islands, showing variations.

VI. NACHTRAG ZUR KENNTNIS DER PHILIPPINISCHEN RUTELIDEN (COLEOPTERA, LAMELLICORNIA)

Von F. OHAUS

Mainz, Germany

FIER FIGUREN

Kürzlich erhielt ich von den Herren Dr. O. Staudinger und A. Bang-Haas, Dresden-Blasewitz, eine grössere Sendung Ruteliden zur Determination zugeschickt, darunter auch die Doubletten derjenigen Arten, welche Herr Georg Böttcher während seiner Reisen auf den Philippinen gesammelt hatte. Unter diesen entdeckte ich mehrere neue Arten—leider nur in je 1 Exemplar—deren Beschreibung ich hiermit bekannt gebe.

PARASTASIA NIGROSCUTELLATA Ohaus.

Von dieser seltenen Art, von der ich bisher nur zwei Exemplare in die Hände bekam, sammelte Herr O. Schütze in San Antonio bei Laguna, Luzon, einen ♂, bei welchem die ganze Unterseite, Afterdecke und Beine schön rotgelb sind; oben ist der Thorax rotgelb mit zwei kleinen schwarzen Flecken, der ganze Kopf, das Schildchen und die Deckflügel einfarbig schwarz. Forceps wie bei der Nominatform.

POPILLIA FURCULA sp. nov.

Der *macronyx* Ohaus zunächst verwandt, oval, flach gewölbt, hinter den Schultern verbreitert und nach hinten verschmälert. Oben und unten nebst den Beinen gleichmässig glänzend schwarz; oben die Umrandung des Thorax, der Hinterrand des Propygidiums und vier scharf begrenzte Fleckchen auf dem Pygidium, unten eine Querreihe auf den Abdominalsterniten und die Seiten sowie die Epimeren der Hinterbrust mit weissen Schuppenhaaren. K o p f schild trapezförmig, wie die flach eingedrückte Stirn dicht runzelig,

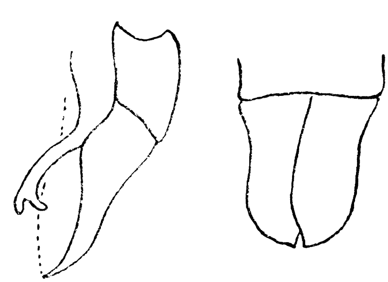

FIG. 1. *Popillia furcula* sp. nov., Forceps.

Scheitel mehr einzeln punktirt. Halsschild vorn und an den Seiten dicht und grob züsammenfliessend punktirt, mit Bogenstricken, die um die hintere Parthie der Scheibe herumlaufen, diese selber sowie die Parthie vor dem Schildchen fein einzeln punktirt; ebenso ist das Schildchen punktirt. Auf den Deckflügeln ist die Parthie neben den stark vorspringenden Schultern und die Scheibe flacher eingedrückt als bei der *macronyx*, die primären Pünktreihen sind fein gefurcht, Rippen und Interstitien kaum gewölbt. Propygidium dicht und fein einzeln punktirt. Pygidium mit grossen Punkten, die nur auf der Spitze einzeln stehen, sonst in quer verlaufende Bogenlinien zusammenfliessen; in den Vorderecken je ein kleines Grübchen. Aüf den Bauchringen ist die Querreihe von Borstenpunkten in der Mitte unterbrochen, die weissen Schuppenhaare an den Seiten dichter stehend. Mesosternalfortsatz gross und kräftig, seitlich zusammengedrückt, etwas gesenkt und gerundet. Beine und Füsse kräftig. Am Forceps, Fig. 1, sind die breiten flachen Parameren vorn gleichmässig zugespitzt; die Ventralplatte des Mittelstücks ist wie ein Unterschnabel nach oben gekrümmt, die Spitze breit gegabelt.

Länge 9.5 bis 10 mm., Breite 5.5 bis 6 mm. ♂ ♀. Süd-Luzon (*G. Böttcher*).

ANOMALA MURICATA sp. nov.

Aus der Gruppe der *A. ovatula* Ohaus. Kurz eiförmig, gut gewölbt, dunkelbraun mit erzgrünen und kupfrigen Lichtern, lebhaft glänzend, oben kahl, unten spärlich und kurz gelb behaart. Kopfschild trapezförmig mit kräftig aufgebogenem Rand, Stirnnaht in der Mitte eingedrückt, die Stirn abgeflacht, wie Kopfschild dicht mit kräftigen zusammenfliessenden Punkten bedeckt, kupfrig, während der erzgrüne Scheitel mit kräftigen einzelnen Punkten dicht besetzt ist. Thorax mit Seitengrübchen und feiner Randfürche ringsum, wie Scheitel und Schildchen einzeln dicht grob punktirt. Auf den Deckflügeln sind die primaren Punktreihen tief gefurcht, Rippen und Interstitien gleich hoch gewölbt, im subsuturalen Interstitium zwei secundäre Rippe, die durch eine vorn unregelmässige Punkti-

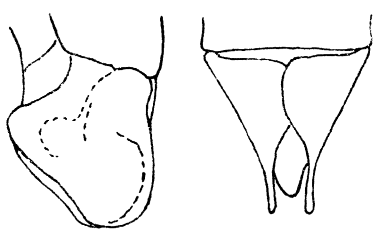

FIG. 2. *Anomala muricata* sp. nov., Forceps.

rung breit getrennt sind, im II. und III. Interstitium zwei, in den seitlichen Interstitien je eine secundäre Rippe. Pygidium ziemlich flach und seitlich nebender Spitze etwas eingedrückt, mit grossen in die Quere gezogenen und zusammenfliessenden Punkten; Spitze und Seiten mit einzelnen Borsten; ebenso ist die Unterseite sculptirt und behaart. Fühler kräftig, gelb, die keule so lang als die Geissel. Forceps Fig. 2.

Länge 10.5 mm., Breite 6.5 mm. ♂. Palawan (*Staudinger*).

ANOMALA NOCTURNA sp. nov.

Aus der Gruppe der *A. leotaudi* Blanchard. Länglich eiförmig, gewölbt. Oben und unten dunkel rotbraun, glänzend, auf Kopf, Halsschild und Schildchen mit grünem Erzschimmer, die Fühler braungelb. Kopfschild trapezförmig, der schwarze Rand hoch aufgebogen, die Fläche wei die abgeflachte Stirn mit groben, zusammenfliessenden Punkten dicht bedeckt, kupferig, während der Scheitel mit einzelnen kräftigen Punkten überstreut erzgrün ist. Thorax ringsum fein gerandet, ohne Seiten grübchen, wie das Schildchen überall dicht und stellenweise zusammenfliessend punktirt. Aüf den Deckflügeln sind die primären Pünktreihen fein gefurcht, die Rippen nicht höher gewölbt als die Interstitien, im subsuturalen Interstitium eine dichte unregelmässige Pünktirung, im II und III. Interstitium je eine einfache Punktreihe, die Punkte vielfach quer eingedrückt, das Gewebe zwischen ihnen zu feinen Querrunzeln erhoben und hierdurch sowie eine Menge feiner Pünktchen die Sculptur etwas undeutlich; der Seitenrand mit langen, abstehenden braunen Borsten. Pygidium dicht querrunzelig, am Rand und auf der Spitze mit langen Borsten. Unterseite dicht runzelig punktirt, die Brust dicht, die Bauchseiten und Beine spärlicher braun behaart. An den Vorderschienen ist der Seitenzahn hinter dem Spitzenzahn kräftig; Mittel- und Hinterschienen mit zwei schiefen Stachelkanten. An den Vorderfüssen trägt die grössere innere Klaue an der dorsalen Kante vor der Spitze eine Borste, die Spitze ist einfach; an den Mittelfüssen ist die grössere äussere Klaue an der Spitze ganz schwach eingeschnitten; an den Hinterfüssen sind beide Klauen einfach,

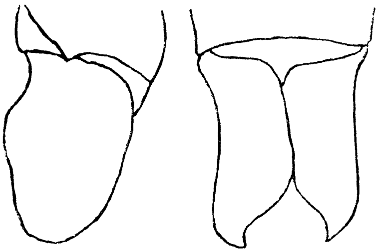

FIG. 3. *Anomala nocturna* sp. nov., Forceps.

nahezu gleich lang. Die Fühlerkeule ist so lang als die Geissel. Am Forceps, Fig. 3, sind die einfachen kleinen Parameren symmetrisch.

Länge 11.5 mm., Breite 6.5 mm. ♂. LUZON, Baguio (*G. Böttcher*).

EUCHLORA NERISSA sp. nov.

Der *E. ceramopyga* Ohaus zunächst verwandt. Länglich eiförmig, mässig gewölbt. Oberseite gleichmässig blattgrün, die Seiten des Thorax schmal gelb; Pygidium gleichmässig erzgrün; Unterseite, Schenkel und Fühler hell rötlichgelb, die Schienen und Füsse erzgrün. Pygidium ganz kahl; Abdominalsternite mit einer Querreihe von Borstenpunkten; die Brust ganz spärlich und Kurz behaart. Kopfschild und Stirn fein zusammenfliessend punktirt, der Scheitel mit einzelnen feinen Pünktchen. Thorax ziemlich dicht bedeckt mit Pünktchen, die in der Mitte sehr fein, an den Seiten etwas stärker sind. Die Deckflügel sind sehr glänzend, wie mit einem feinen Firnis bedeckt und tragen überall sehr feine, nur unter der Lupe sichtbare Pünktchen; neben der Schülter–Apicalbuckel–linie eine Reihe kürzer Querfalten. Pygidium dicht bedeckt mit Hufeisenpunkten, die der Quere nach zusammenstossen, Querrunzeln und hier und da kleine Höckerchen bilden. Abdominalsternite an den Seiten fein runzelig punktirt. Am Forceps, Fig. 4, tragen die Parameren in der Mitte der Unterseite einen Zahn.

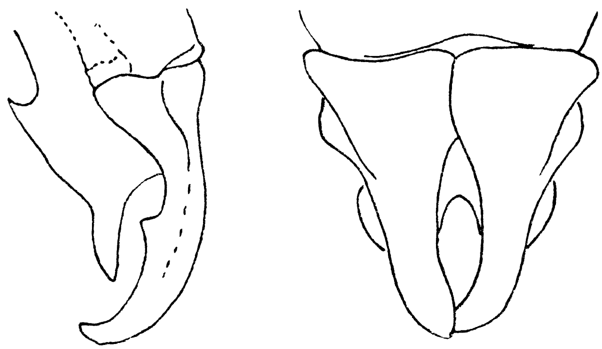

FIG. 4. *Euchlora nerissa* sp. nov., Forceps.

Länge 18.5 mm., Breite 10.5 mm. ♂. MINDANAO, Zamboanga (*G. Böttcher*).

ILLUSTRATIONEN

ABBILDUNGEN IM TEXT

FIG. 1. *Popillia furcula* sp. nov., Forceps.
2. *Anomala muricata* sp. nov., Forceps.
3. *Anomala nocturna* sp. nov., Forceps.
4. *Euchlora nerissa* sp. nov., Forceps.

ALKALOID FROM ANONA RETICULATA LINNÆUS

By ALFREDO C. SANTOS

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Many members of the family Anonaceæ have been found to contain alkaloids. De Rochebrune [1] isolated from the fruits of *Xylopia etiopica* A. Rich. an alkaloid crystallizing in long fine prisms which he called anonaceine. De Rochebrune [2] mentions the occurrence of anonaceine in several plants belonging to the Anonaceæ. J. Marañon [3] isolated artabotrine ($C_{36}H_{55}O_6N$), melting point, 187° C., from the bark of *Artabotrys suaveolens* Blume.

In the genus *Anona*, there are three species found in the Philippines; two of these have been reported to contain alkaloids. Callan and Tutin [4] in the process of a chemical examination of the leaves, reported the presence of an amorphous alkaloid in *Anona muricata* Linnæus. N. Trimurti [5] found in the leaves of *Anona squamosa* Linnæus a white powdery base which occurred in the amount of 0.4 per cent calculated as chloroplatinate.

According to the literature there is no work done on the isolation of an alkaloid from *Anona reticulata* Linnæus, the third species of *Anona*, a tree that is extensively cultivated in the Philippines. Therefore, it was thought that it would be interesting to find out if, as expected, this species also contained an alkaloid. The plant is commonly known as "anonas." According to Pardo de Tavera,[6] the green fruit is used to check diarrhœa and dysentery on account of the large quantity of tannin it contains. The juice of the trunk is irritant. The leaves and the fruit of *Anona reticulata* Linnæus are official in the first

[1] Pharm. Rundschau Nr. 34 (1901), through Pharm. Ztg. 46 (1901) 693–694.

[2] Toxicologie Africaine 1 (1897) 385.

[3] Philip. Journ. Sci. 38 (1929) 259–265.

[4] Phar. Journ. IV 33 (1911) 743.

[5] Jour. Ind. Inst. Sci. 7 (1924) 232–234, through Chem. Abs. 1 (1925) 656.

[6] Plantas Medicinales de Filipinas, Madrid (1892) 22.

to the fourth edition of the Mexican Pharmacopœia.[7] In the present investigation, an alkaloid melting at 122 to 123° C. was isolated from the bark of the trunk of *Anona reticulata* Linnæus grown in the neighborhood of Manila. From the results of the elementary analysis, molecular-weight determination, and analysis of the hydrochloride the alkaloid corresponds to the formula $C_{17}H_{16}NO_3$. It does not contain a methoxyl group. Of the three oxygen, two are in the form of a dioxymethylene group. In order to distinguish the alkaloid from those obtained by previous investigators from other plants of the family Anonaceæ the writer proposes to name it "anonaine."

The bark examined was found to contain 0.03 per cent anonaine. Because of the small yield and the small amount of the alkaloid that was obtained, the writer discontinued the work temporarily.

EXPERIMENTAL

A quantity of the powdered, air-dried bark weighing 1.8 kilograms was refluxed three times with the same volume of 95 per cent alcohol on the water bath for about three hours. The alcohol was recovered from the combined alcoholic extracts at first by distillation, afterwards by evaporation on a water bath, until the odor of alcohol was no longer perceptible. The sirupy brownish residue was acidified distinctly with acetic acid and treated with water. This treatment caused a separation of a resinous matter.

The aqueous acid solution was shaken out with ether and rendered alkaline with ammonia. The ethereal solution was shaken with 5 per cent sodium hydroxide solution repeatedly until no more phenolic bases went into the alkali. On treating the ethereal solution with dilute hydrochloric acid, the hydrochloride crystallized out. This was filtered, recrystallized, again dissolved in water, shaken out with ether, and alkalinified with ammonia. On evaporation of the ether the alkaloid crystallized in long needles melting at 122 to 123° C. The yield was about 0.25 gram.

The sodium hydroxide solution was acidified, shaken out with ether, and made alkaline with ammonia. On evaporation of the ether there remained about 0.1 gram residue. On account of its small quantity it was not studied further.

[7] Bruntz, L., and M. Jaloux, Plantes Medicinales et Plantes a Drogues Medicamenteuses. Paris (1918) 68.

To recover the alkaloid contained in the resinous matter, the material was dissolved in dilute sodium hydroxide and the alkaloid extracted shaken out with ether. When the ether extract was treated with dilute hydrochloric acid the insoluble hydrochloride separated out again. It was treated further as above. The yield from the resin was about 0.33 gram. More than one-half of the alkaloid was thus contained in the resin.

From 1.8 kilograms of bark about 0.7 gram of alkaloid was obtained. The alkaloid is slightly levorotatory.

0.0836 gram of substance dissolved in 10 cubic centimeters of chloroform gave a specific rotation $[\alpha]_{D}^{32.5^\circ C.}$ of -83.01°.

The base was dried to constant weight over calcium chloride in a vacuum:

Analysis:

Analysis No.—	Substance.	Carbon dioxide.	Water.	Nitrogen.
	mg.	*mg.*	*mg.*	*cc.*
1	5.920	15.681	2.956	
2	5.864	15.592	3.217	
3	5.955	15.904	3.052	
4	6.135			0.276 (34° C; 761 mm.)
5	5.943			0.247 (32° C; 762 mm.)

	Carbon.	Hydrogen.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*
Calculated for $C_{17}H_{16}NO_3$	72.3	5.7	5.0
Found	72.2	5.6	4.9
	72.5	6.1	4.8
	72.8	5.7	

Molecular weight determination according to Rast gave the following results:

Experiment No.—	Substance.	Camphor.	Depression.
	mg.	*mg.*	*°C.*
1	1.270	9.877	18
2	2.592	18.436	20.5

	Molecular weight.
Calculated for $C_{17}H_{16}NO_3$	282
Found	285.7
	274.4

The hydrochloride crystallizes from water in the form of fine silky needles. It did not lose weight on drying over phosphorus pentoxide (80°C) in a vacuum.

Analysis:

63.803 mg substance gave 28.460 mg AgCl

	Chlorine. Per cent.
Calculated for $C_{17}H_{16}NO_3HCl$	11.0
Found	11.1

The chloroplatinate was obtained as a yellow amorphous precipitate by treating a solution of the hydrochloride, acidified with hydrochloric acid, with a slight excess of chloroplatinic acid. It does not crystallize either from alcohol or dilute acids. It was filtered and washed with water acidulated with hydrochloric acid.

The chloroplatinate did not lose weight on drying over phosphorus pentoxide (80°C) in a vacuum:

Analysis:

Analysis No.—	Substance.	Platinum.
	mg.	*mg.*
1	57.778	11.805
2	45.225	9.305

	Platinum. Per cent.
Calculated for $(C_{17}H_{16}NO_3HCl)_2PtCl_4$	20.04
Found	20.43
	20.57

	Molecular weight of free base.
Calculated for $C_{17}H_{16}NO_3$	282.0
Found	272.4
	269.3

Methoxyl determination according to Zeisel-Pregl gave negative results. The qualitative detection of a dioxymethylene group according to Gaebel showed distinctly the presence of a methylene dioxide group.

ACKNOWLEDGMENT

The author wishes to express his thanks to Dr. Leon M. Guerrero for suggesting this investigation on the Anonaceæ.

CARBOHYDRATE AND SEROLOGICAL DETERMINATIONS OF THE BIPOLAR GAS-FORMING AND NON-GAS-FORMING ORGANISMS ISOLATED FROM LYMPH GLANDS OF SLAUGHTERED CATTLE

By ONOFRE GARCIA

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In 1927 three strains of gas-forming bipolar organisms were reported.[1] They were isolated from slaughtered cattle. The investigation was extended with a view to find other types of these organisms, taking advantage of the ease of isolating them in pure culture from such organs. The first sample of glands investigated was from a cow which came from Palawan Province, and the second sample was from a cow slaughtered at Sisiman Slaughter House. The strain isolated from the first sample was labeled G–4 and that from the second sample G–5. These two strains were studied and compared with the three strains of bipolar organism that were previously reported.

The procedure of isolation was the same as given in the previous report; that is, the gland was dissected, sterilized superficially, and cut; the internal portion was scraped, triturated in a sterile mortar, and diluted with salt solution. One cubic centimeter of this solution was injected subcutaneously. Upon the death of the animal cultures were made from the heart, the liver, and the spleen.

The strain G–4 (Table 1) was a gas-forming bipolar organism and presented cultural characteristics similar to those of the three strains previously reported (Table 1, G–1, G–2, and G–3). The strain G–5 (Table 1) showed the following biochemical characteristics. It was a non-gas-forming bipolar organism,

[1] Philip. Journ. Sci. 33 (1927) 331.

TABLE 1.—*Showing the carbohydrate reactions.*

[+, acid only; ++, acid and gas; F, faintly acid; 0, negative.]

Carbohydrates, 1 per cent.	Peptone-salt solution with Andrade indicator in Durham's fermentation test tubes.														
	April 29, 1927.					May 2, 1927.					May 5, 1927.				
	G–1	G–2	G–3	G–4	G–5	G–1	G–2	G–3	G–4	G–5	G–1	G–2	G–3	G–4	G–5
Glucose	+	+	+	+	+	++	+	++	++	+	++	+	++	++	+
Galactose	+	+	+	+	+	++	+	++	++	+	++	+	++	++	+
Levulose	+	+	+	+	+	++	+	+	+	+	++	+	+	+	+
Arabinose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xylose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhamnose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maltose	+	+	+	+	+	++	+	+	+	+	++	+	+	+	+
Lactose	0	F	F	0	F	0	F	F	0	F	0	0	0	0	0
Sucrose	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
Amygdalin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salicin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raffinose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dextrin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorbitol	+	+	+	+	+	++	++	++	++	+	++	++	++	++	+
Dulcitol	+	+	+	+	0	++	++	++	++	0	++	++	++	++	0
Mannitol	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
Glycerol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Adonitol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inositol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nutrose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aspargin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inulin	+	+	+	+	+	++	++	++	++	+	++	++	++	++	+
Erythritol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mannose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Gram-negative, and nonmotile. It grew on blood agar heated to 70° C. and showed a translucent, slightly elevated, grayish colony; the pheriphery was regular. It produced a uniform turbidity in ordinary bouillon which occasionally showed a very thin pellicle after four or five days incubation. Sediment was formed at the bottom a little later. On ordinary acid agar, if it grew at all, the growth was slow and scanty, similar to that of streptococcus. There was reduction in nitrate broth.[2] The nitroso-indol reaction was positive in forty hours. No gas developed in the Smith fermentation tube containing infusion broth to which 1 per cent glucose was added.

Rabbits and guinea pigs died within two or three days after inoculation with living cultures. The two strains (G–4 and G–5) did not grow on eosin-methylene blue-lactose agar.

In order to establish the identity of the two newly isolated strains (G–4 and G–5) with those that were already reported (G–1, G–2, and G–3) the following studies were made: First, the study of their behavior towards various sugars; second, the study of the gas production in culture media; and third, serological study.

BIOCHEMICAL REACTIONS

The five strains were inoculated in Dunham's solution containing 1 per cent of various carbohydrates with 1 per cent Andrade's indicator adjusted to such a reaction that when heated it turned pink and became colorless when cool. Normal solution of sodium hydroxide was used to adjust this reaction.[3]

As seen in Table 1, the strains G–1, G–2, G–3, and G–4 fermented glucose, galactose, levulose, maltose, sorbitol, dulcitol, inulin, and mannose. There was gas formation in most of the fermented sugars. The strain G–5 fermented glucose, galactose, levulose, maltose, sucrose, sorbitol, mannitol, inulin, and mannose. It did not produce gas after incubation for one week.

Sugar-free infusion broth was planted along with Dunham's solution. The results of the sugar reactions in both basic media were the same. However, the formation of gas was evidently more pronounced in the infusion broth than in Dunham's solu-

[2] One per cent peptone was used instead of 0.1 per cent.

[3] In the Philippine Journal of Science 33 (1927) page 338, third line, *for* 0.1 *N.* *read* 1.0 *N.*

TABLE 2.—*Showing carbohydrate reactions with the subsequent formation of gas in two basic media.*

[+, acid only; ++, acid and gas; 0, negative; B, bubble; n, not used.]

Carbohydrate, 1 per cent.	Media.	Sugar-free infusion broth, peptone salt water, with Andrade indicator in Durham fermentation tube. Inoculated August 20, 1927.																			
		August 21, 1927.					August 24, 1927.					August 27, 1927.					September 1, 1927.				
		G-1	G-2	G-3	G-4	G-5	G-1	G-2	G-3	G-4	G-5	G-1	G-2	G-3	G-4	G-5	G-1	G-2	G-3	G-4	G-5
Glucose Merck	Infusion	+	+	+	+	+	+	++	++	++	+	+	++	++	++	+	+	++	++	++	+
	Peptone	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Maltose Pfanstiehl	Infusion	+	+	+	+	+	++	++	++	++	+	++	++	++	++	+	++	++	++	++	+
	Peptone	+	+	+	+	+	++	+	+	++	+	++	+	+	++	+	++	+	+	++	+
Mannite Merck	Infusion	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
	Peptone	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
Saccharose Merck	Infusion	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
	Peptone	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+	0	0	0	0	+
Sorbite Pfanstiehl	Infusion	+	+	+	+	+	B	+	B	B	+	++	++	++	++	+	++	++	++	++	+
	Peptone	+	+	+	+	+	++	+	++	++	+	++	+	++	++	+	++	+	++	++	+
Dulcite Pfanstiehl	Infusion	+	+	+	+	0	++	+	+	++	0	++	++	B	++	0	++	++	++	++	0
	Peptone	+	+	+	+	0	+	+	+	+	0	+	+	+	+	0	+	+	+	+	0
Levulose Pfanstiehl	Infusion	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	Peptone	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Galactose Eimer and Amend	Infusion	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Peptone	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Mannose Merck	Infusion	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	Peptone	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

tion. The number of tubes showing gas was, of course, less in the latter than in the former basic medium (Table 2). It was observed that carbohydrates in fermentation test tubes stored in the ice box for more than one month gave, when inoculated, irregular fermentation reactions. Therefore, sugars with the indicator herein employed should be used within one week.

TABLE 3.—*Showing the result of gas production in Smith fermentation tube. The closed arm measures 1.2 by 10 centimeters. One per cent carbohydrate with no indicator. Autoclaved fifteen minutes at 15 pounds. Result of one week incubation.*

[— ×, no gas, the growth reaches the tip of the closed arm; —0, no gas, the growth does not reach the tip of the closed arm; fraction and ×, amount of gas by fraction of a centimeter with growth to the tip of the closed arm.]

Strain.	Glucose.		Maltose.		Mannite.		Sorbite.		Galactose.		Dulcite.		Saccharose.	
	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.
G-1	—×	—0	0.5×	—0	—0	—0	—×	—0	—0	—0	0.6×	—0	—0	—0
G-2	—×	—0	—×	—0	—0	—0	—×	—0	—0	—0	0.5×	—0	—×	—0
G-3	—×	—0	—×	—×	—0	—0	0.2×	—0	—×	—0	0.3×	—×	—0	—0
G-4	—×	—0	0.5×	0.2×	—0	—0	0.2×	—0	—×	—0	0.5×	—0	—0	—0
G-5	—×	—0	—×	—0	—×	—0	—×	—0	—×	—0	—×	—0	—×	—×

GAS FORMATION

The evolution of gas was also studied in the Smith fermentation tube without indicator (Table 3). Here again the amount of gas was constantly greater in the tubes that contained sugar-free infusion broth. The maximum length of the column of produced gas was 3 centimeters when measured shortly after isolation, and at a later date was only 0.5 centimeter long.[4]

The results of the sugar reactions were practically the same in all repeated tests. However, the production of gas was not uniform with the four cultures (G-1, G-2, G-3, and G-4). It also varied with the particular carbohydrates, becoming less in the course of time. The resulting carbohydrate reactions were

[4] Philip. Journ. Sci. 33 (1927) Table 1.

checked by titrating the acidity against N/20 sodium hydroxide (Table 4).

TABLE 4.—*Showing the results of titration after one week incubation.*

Strain.	Glucose.		Maltose.		Mannite.		Sorbite.	
	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.
G-1	1.10	0.85						
G-2			1.35	0.90				
G-3					0.50	0.35		
G-4							1.30	0.75
G-5	1.00	0.75	1.20	0.90	1.20	0.65	1.20	0.70
Control	0.50	0.50	0.60	0.50	0.50	0.40	0.60	0.55

Strain.	Galactose.		Dulcite.		Saccharose.	
	Infusion.	Peptone.	Infusion.	Peptone.	Infusion.	Peptone.
G-1					0.85	0.70
G-2			1.10	0.75		
G-3	1.10	0.70				
G-4						
G-5	1.05	0.70	0.40	0.35	2.00	1.20
Control	0.65	0.50	0.50	0.40	0.90	0.70

SEROLOGY

Homologous sera were produced in rabbits with each of the five strains. With these sera cross-agglutination reactions were performed the results of which are recorded in Table 5. It shows that there are two serologically distinct types. The first four strains (G–1, G–2, G–3, and G–4) form a separate type; and the fifth strain (G–5) forms by itself another type. Absorption tests were also performed with the strains G–1, G–2, G–3, and G–4, using their respective homologous sera. Each strain absorbed its own agglutinins completely (Table 6). No absorption test was made with strain G–5.

An antihæmorrhagic cattle septicæmia serum [5] was obtained, and agglutination reactions were performed with the strains G–1, G–2, G–3, G–4, and G–5. As may be seen in Table 7 there was a low-grade but marked agglutination reaction noticeable with strain G–5.

[5] Dr. R. Gonzales, an agent of the Jensen Salsbery Laboratory, United States of America, kindly supplied this serum.

TABLE 5.—*Showing the results of cross agglutination reactions.*

Strain.	Serum G-1.				Serum G-2.				Serum G-3.			
	1 : 100	1 : 200	1 : 400	1 : 800	1 : 100	1 : 200	1 : 400	1 : 800	1 : 100	1 : 200	1 : 400	1 : 800
G-1	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
G-2	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
G-3	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
G-4	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++	++++
G-5	—	—	—	—	—	—	—	—	—	—	—	—

Strain.	Serum G-4.				Serum G-5.				Control, salt solution.
	1 : 100	1 : 200	1 : 400	1 : 800	1 : 100	1 : 200	1 : 400	1 : 800	
G-1	++++	++++	++++	++++	—	—	—	—	—
G-2	++++	++++	++++	++++	—	—	—	—	—
G-3	++++	++++	++++	++++	—	—	—	—	—
G-4	++++	++++	++++	++++	—	—	—	—	—
G-5	—	—	—	—	++++	++++	++++	++++	—

TABLE 6.—*Showing the results of absorbed sera by their homologous antigens with unabsorbed sera as controls.*

Strain.	Absorbed and unabsorbed sera.					
	G-1			G-2		
	1 : 100	1 : 200	Control 1 : 200	1 : 100	1 : 200	Control 1 : 200
G-1	—	—	++++	—	—	++++
G-2	—	—	++++	—	—	++++
G-3	—	—	++++	—	—	++++
G-4	—	—	++++	—	—	++++
Strain.	Absorbed and unabsorbed sera.					
	G-3			G-4		
	1 : 100	1 : 200	Control 1 : 200	1 : 100	1 : 200	Control 1 : 200
G-1	—	—	++++	—	—	++++
G-2	±	—	++++	—	—	++++
G-3	—	—	++++	—	—	++++
G-4	—	—	++++	—	—	++++

TABLE 7.—*Showing the result of agglutination test of the five strains against the antihæmorrhagic septicæmia serum (for cattle).*

[Jensen Salsbery Laboratory, U. S. A.]

Polyvalent serum dilution.	G-1	G-2	G-3	G-4	G-5
1 : 25	—	—	—	±	++++
1 : 50	—	—	—	—	+++
1 : 100	—	—	—	—	+++
1 : 200	—	—	—	—	+
1 : 400	—	—	—	—	±
1 : 800	—	—	—	—	—
Control	—	—	—	—	—

COMMENTS

The gas-forming organisms hitherto studied and described were found to give biochemical reactions distinct from those of the ordinary non-gas-forming organisms. Their morphology, cultural characteristics, and behavior with regard to the production of agglutinins approximate those of the group of non-gas-forming organisms. The non-gas-forming bacteria, described in this paper, were undoubtedly *B. bovisepticus*.

In immunizing rabbits about five slants were needed to produce a titer of 1 to 800 for over a period of forty-six days. With strain G–5 a serum of a higher titer (1 to 3,200) was obtained, using the same amount of antigen for the same length of time as was required for the other strains.

One rabbit, which received one slant of killed culture over a period of fourteen days, revealed no agglutinins in its blood in a dilution of 1 to 50. Other rabbits, which received intravenously for over forty-six days $1\frac{3}{4}$ slants heated to 56° C., did not show the presence of agglutinins in the dilution of 1 to 50; but a single injection of three-fourths of a slant of living culture produced immediately a rapid increase of agglutinins in a dilution of 1 to 640 in the same rabbit (Table 8).

As noted by L. M. Roderick,[6] L. Barnes,[7] and others, the immunity might set in before the antibodies were demonstrable in the blood. The process of immunization may be further advanced with the use of living organisms.

TABLE 8.—*Showing the procedure of immunization to produce agglutinating sera in rabbits.*

Strain.	Vaccine heated to—	Injection.	Amount (slants) injected.	Days of immunization.	Titer of serum.
	°C.				
G–1	56	Intravenous	1	14	1 : 50 = 0
	56	do	3	23	1 : 200
	50	do	[a] 1	13	1 : 800
G–2	56	do	2.75	23	1 : 200
	50	do	[a] 1	13	1 : 800
G–3	56	do	1	14	1 : 50 = 0
	56	do	3	23	1 : 200
	50	do	[a] 1	13	1 : 800
G–4	56	do	1	14	1 : 50 = 0
	56	do	3	23	1 : 200
	50	do	[a] 1	13	1 : 800
G–5	56	do	4.5	46	1 : 3200
G–1	56	Intravenous	1.75	46	1 : 50 = 0
	([b])	Subcutaneous	[a] 0.75	15	1 : 640
G–4	56	Intravenous	1.75	46	1 : 50 = 0
	([b])	Subcutaneous	[a] 0.75	15	1 : 640

[a] Once. [b] Alive.

The difficulty of producing serum of high agglutinating titer in a relatively short time with most of the hæmorrhagic septi-

[6] Journ. Infect. Dis. 31 (1922) 313–325.
[7] Journ. Immunology 15 (1928) 289–297.

cæmia strains has been experienced by other workers. A. Tanabe,[8] working with various strains of hæmorrhagic septicæmia organisms, obtained an agglutination titer of 1 to 640.

G. E. Jorgenson[9] obtained a titer of 1 to 500 after the injection of killed cultures over a period of thirty-one days, but a clear cut agglutination was not so prompt as is usual with other bacteria. Further treatment with killed cultures to increase the titer of this serum to 1 to 5,000 was possible according to him.

The above observations were also noted in my experimental animals, and the absorption reaction was not difficult, being applied once only.

It is known from the study made by V. A. Moore[10] that the hæmorrhagic septicæmia organisms are found in the air passages of apparently healthy animals in the proportion of about 80 per cent in cattle; and about 48 per cent in hogs that were examined by him. Lately G. E. Jorgenson[11] resumed the study of hæmorrhagic septicæmia organisms from two hundred fifty normal cattle of which thirty-seven animals harbored in their nasal passages the *Pasteurella* organisms.

The gas-forming bipolar organisms were also encountered in some animals with symptoms of hæmorrhagic septicæmia. However, very little study was made in this direction. The finding of the two distinct types, gas-forming and non-gas-forming bacteria, in the deeper organs such as lymphatic glands suggests that both types may, independently, produce the same type of disease, attributed solely to non-gas-forming hæmorrhagic septicæmia organisms. However, this concept requires further analysis of cases studied by experimental procedures.

The finding of a hæmorrhagic septicæmia organism in the lymphatic glands indicates its natural route. The blood stream is invaded in due time when the resistance of the animal becomes lowered. The disease has a rapid course. "Some animals, which are apparently healthy, will turn around once or twice and drop dead; or, if tied by halter will apparently try to break loose from their manger and drop dead."[12]

[8] Journ. Infect. Dis. 33 (1926) 241–248.

[9] Cornell Veterinarian 15 (1925) 295–302.

[10] U. S. Dept. Agr. Bur. of Animal Industry, Bull. 3.

[11] Cornell Veterinarian 15 (1925) 295–302.

[12] Philip. Agr. Rev. 1 (1908) 135.

SUMMARY AND CONCLUSIONS

1. Both gas-forming and non-gas-forming bipolar organisms were isolated from the lymphatic adenitis of slaughtered cattle. They are morphologically alike.

2. The gas-forming organism fermented glucose, galactose, levulose, maltose, sorbitol, dulcitol, inulin, and mannose. The non-gas-forming organism fermented glucose, galactose, levulose, maltose, sucrose, sorbitol, mannitol, inulin, and mannose. Therefore, the organism was identified as *B. bovisepticus*. Neither type grew on eosin-methylene blue-lactose agar. Each type gave definite and distinct biochemical and serological reactions of its own.

3. Both types were pathogenic for rabbits and guinea pigs.

4. Some immunological phenomena, like the early appearance of immunity before antibodies are demonstrable commonly noted by some workers with hæmorrhagic septicæmia organisms, were likewise observed in the animals injected with our gas-forming bacteria.

ACKNOWLEDGMENT

I wish to express my most sincere thanks and appreciation to Dr. R. B. de Leon, of the Philippine Health Service, for supplying the materials of study, and to Dr. Otto Schöbl, chief of the division of biology and serum laboratory, Bureau of Science, for his kind assistance.

CULTIVATION OF AN ACID-FAST BACILLUS FROM LEPROSY

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ONE PLATE

The combat against leprosy would be greatly aided by the cultivation of Hansen's bacillus, and by the discovery of preparations of the antigen suitable for determining susceptibility to, and creating immunity against, the disease. The exacerbations in leprosy are characterized by marked hypersensitivity and it might well be that desensitization would contribute to its therapy.

When cultivating bacteria one must furnish suitable respiratory conditions as well as proper food. Since the writer and Ervin [1] had shown that carbon dioxide (CO_2) was essential for the growth of *B. tuberculosis*, and since Rockwell [2] had demonstrated the same fact for all of a number of other bacteria, special attention was given to this fact in the attempt to cultivate Hansen's bacillus. Variations in the oxygen (O_2) and carbon dioxide (CO_2) supply were brought about as follows:

(*a*) *Aërobic.*—The culture tubes were left uncapped, or when covered by a rubber cap, a fine syringe needle inserted through the cap allowed air to enter.

(*b*) *Little oxygen (O_2) and increased amount of carbon dioxide (CO_2).*—The culture tubes were attached by means of gum rubber tubing to agar slants which had been inoculated with *B. coli.*

(*c*) *Oxygen (O_2) and carbon dioxide (CO_2).*—The tubes were prepared as in (*b*) and then a fine syringe needle was inserted through the connecting rubber tubing and the point of the needle buried in the cotton plug of the culture tube.

(*d*) *No oxygen (O_2) but carbon dioxide (CO_2) present.*—The anaërobic condition was brought about by Rockwell's method (pyrogallic acid and sodium bicarbonate).

[1] Journ. Infec. Dis. 22 (1918) 194.
[2] Journ. Infec. Dis. 32 (1923) 98.

CULTIVATION EXPERIMENTS

Several native fruits and vegetables autoclaved in 3 per cent glycerin solution were used. These were the mango, papaya, lansone, bean, opo, yellow squash, its seeds, ampalaya, taro, eggplant, and togue (germinated mongo beans). When planted upon or in these media, the lepra bacilli were recovered in smears a few days after inoculation and for as long as seven to fourteen days in some instances, but there were no signs that the bacilli had multiplied. Sometimes intact nucleated lepra cells containing stainable nuclei and numerous acid fasts were seen. There was no proliferation on 3 to 6 per cent glycerin agar or glycerin agar containing human blood.

The growth described below was obtained in a modification of glycerin agar containing hen's ovomucoid and yolk. The preparation of this is as follows:

The white of a hen's egg is boiled in 100 cubic centimeters of distilled water containing 3 to 6 per cent glycerin. This is filtered through cotton. About one-half of the yolk of the egg is thoroughly mixed with the filtrate and boiled. This is filtered through gauze in order to allow the finer yolk particles to pass the filter. This is then autoclaved at 20 pounds for twenty minutes. In the following experiments the glycerinized ovomucoid yolk and nutrient agar containing 2 per cent of agar were mixed aseptically in equal proportions. This medium is semisolid. The planted lepra bacilli tend to persist for several weeks upon this medium, and in one instance where this medium contained 1 to 10,000 gentian violet, the acid-fast bacilli persisted without apparent multiplication for more than three months under respiratory conditions (*b*) and (*d*).

In the attempt to stimulate growth, small amounts of various substances were added; for example, potassium dihydro-phosphate (KH_2PO_4), sodium hydrogen phosphate (NA_2HPO_4), calcium chloride ($CaCl_2$), magnesium nitrate ($MgNO_3$), potassium iodide (KI); and glucose, lactose, saccharose, maltose, mannite; and oleic, palmitic, butyric acids; and peanut oil and lumbang oil.

In most instances these combined media were prepared and used as follows: The autoclaved ingredients were placed in small sterile plugged tubes and mixed by drawing back and forth in a sterile pipette, solidified in a slant position and kept on ice for twenty-four hours in order to allow water of syneresis to col-

lect. As a general rule, 2 to 4 cubic centimeters of media were used.

In most of the experiments the planted bacilli disappeared in a few days, or without signs of multiplication, persisted for one or two weeks. The only combination tried in which multiplication took place was when 1 or 2 drops of autoclaved oleic acid and 1 or 2 drops of a 10 per cent dextrose autoclaved in distilled water were added to each cubic centimeter of the glycerinized agar ovomucoid yolk medium.

I am indebted to Dr. E. V. Pineda, of San Lazaro Hospital, for his assistance in making the cultures. Recently discovered cases that had not been treated were chosen. The skin over the leprous lesion was cleaned with iodine and alcohol, and blood containing lepra bacilli was obtained on the edge of a sterile knife by the routine "snip" method. One loopful of blood was then transferred by means of a sterile platinum loop to the water of syneresis in the culture tubes. Control smears showed that numerous lepra bacilli were always transferred in the loopful.

None of the cultures was contaminated by cocci or diphtheroids from the skin. Cultures from three cases of leprosy, kept at 35° to 37° C. showed decided proliferation at the end of four to six weeks. The best growth was obtained in cultures that were kept first at partial oxygen tension [little oxygen (O_2) but carbon dioxide (CO_2) present] for a month, after which the tubes were kept under oxygen (O_2) and carbon dioxide (CO_2). Proliferation is recognized only by making smears of the semisolid culture medium. It is important that the contrast stain, Löffler's methylene blue, should be diluted for a too dense staining of the medium will obscure many of the fine acid-fast rods. The nuclei of planted lepra cells disappeared and the microscopic colonylike masses of acid-fast rods increased in number for a few weeks and then the growth appeared to be stationary (Plate 1).

Subculture of a loopful of material containing several dozen colonies into the same medium resulted in the appearance of a large number of subcolonies and isolated masses and scattered acid fasts. The subcultures were examined five weeks after inoculation. Two of the primary cultures in the above medium were subcultured successfully in the same medium, but the transplanted bacilli disappeared when they were carried over into various other modifications of the glycerinized ovomucoid yolk

medium. In one instance, the primary culture was three and a half months old and, in another instance, one month old when the subcultures were made.

The rods are thinner than tubercle bacilli, and when Löffler's blue is used as a contrast stain, they often contain one or two blue granules. As in the case of smears from leprosy, if the culture preparations are first treated with xylol and alcohol, the rods do not retain the stain after heating with carbol fuchsin and treating with acid alcohol. This peculiarity of lepra bacilli in smears has been noted also by Dr. E. V. Pineda.

SUMMARY

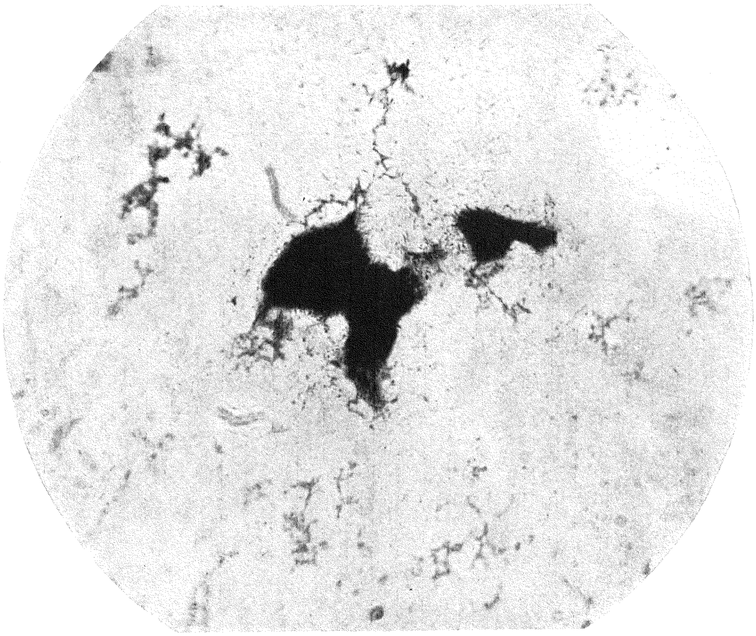
An acid-fast bacillus was grown in a semisolid medium composed of equal parts of nutrient agar, and hen's ovomucoid and yolk, prepared by boiling in 3 to 6 per cent glycerin solution, when there was added to this 1 or 2 drops of oleic acid and 1 or 2 drops of 10 per cent dextrose solution for each cubic centimeter of medium. Multiplication occurred best in cultures incubated at 35 to 37° C., with little oxygen present but carbon dioxide present. Microscopic examination after four to six weeks incubation showed the presence of numerous microscopic colonies. Growth was obtained from three cases. From two of the primary cultures, subcultures were obtained at a time when the primary cultures were three and one-half months and one month old, respectively. Like the lepra bacilli in smears from cases, the cultivated bacilli do not stain by the acid-fast method if they are first treated with xylol and alcohol.

ILLUSTRATION

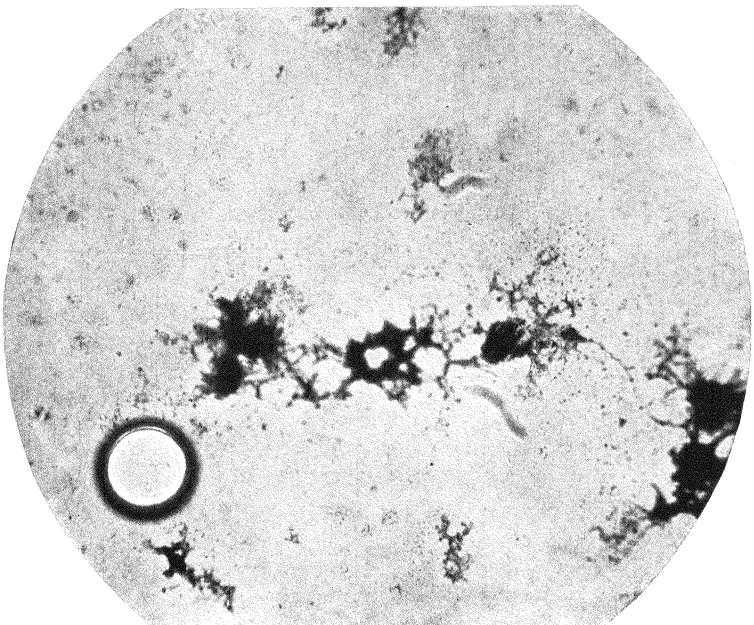
PLATE 1

FIG. 1. One of the larger microscopic colonies. Isolated minute acid-fast bacilli scattered about the neighborhood.

2. Younger, more loosely aggregated masses of growth.



1



2

PLATE 1.

IMMUNOLOGIC RECIPROCITY BETWEEN SYPHILIS AND YAWS [1]

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The effect of infection with syphilis on the development of immunity to yaws was studied in two experiments.

The first experiment was arranged in the same way as were those of the early workers who studied the cross immunity between syphilis and yaws in monkeys. (Neisser, Baermann, Halberstaedter, Castellani, Levaditi, and Larier.)

Monkeys were inoculated with syphilis by intradermal injection of syphilitic material on the scrotum. At intervals of time after this inoculation the animals were inoculated with yaws by intradermal injection in the eyebrows. The intervals of time between the two inoculations ranged from two and one-fourth months to eight months. Every one of the monkeys inoculated with syphilis and giving evidence of syphilitic infection, either by specific lesion, by presence of viable treponemas in the lymph glands, or both, developed yaws at the point of yaws inoculation, which inoculation was performed within seven months after the inoculation with syphilis. The monkey that was successfully inoculated with syphilis and superinoculated with yaws eight months later failed to show yaws lesion on two successive inoculations.

In the second experiment the animals were inoculated with syphilis repeatedly. The subsequent inoculations failed to produce lesions in the syphilitic monkeys, while normal control monkeys showed a typical specific lesion at the place of inoculation with syphilis. The inocula, therefore, contained viable treponemas but the syphilitic monkeys failed to react by specific lesions to the superinoculations with syphilis. Thus it was proven that the animals became immune to syphilis. Following the superinoculation with syphilis the monkeys were

[1] Presented for publication June 4, 1930.

inoculated repeatedly with yaws on the eyebrows, while the previous inoculations with syphilis were performed on the scrotal skin. Normal monkeys were inoculated at the same time with the same amount of the same yaws material and served as controls (see Table 2). The result of the second experiment confirms the findings made in the first one that infection with syphilis confers an immunity to yaws in Philippine monkeys. This cross immunity develops much later than immunity to syphilis in syphilitic monkeys and later than yaws immunity in yaws monkeys.

DISCUSSION

The first and the second experiments give us a good deal of the desired information. They show first of all that Philippine monkeys become immune to syphilis in less than two months after the first intracutaneous inoculation with syphilis; in other words, about as soon as rabbits do. Philippine monkeys inoculated with syphilis become immune to yaws later than yaws monkeys become immune to yaws.

The second experiment shows that intradermal superinfection with yaws of syphilitic monkeys performed after the animals become imune to syphilis but still are susceptible to yaws does not hasten the immunity to yaws. This is naturally to be expected since intradermal superinoculation with yaws of yaws monkeys does not hasten the immunity to yaws within the six months period. The second experiment also demonstrates that superinoculation with syphilis of syphilitic animals, performed in the stage of tissue nonreactivity with regard to syphilis, does not influence the onset of immunity to yaws.

In these experiments the fallacy of the theory of latent infection as a cause of resistance to inoculation in syphilis is again evident. Syphilitic monkeys with syphilitic "latent infection" were not immune to yaws at a time when yaws monkeys without "latent infection", due to either yaws or syphilis, were found on a previous occasion immune to both yaws and syphilis. That this theory is untenable has been pointed out by several workers in the literature. We believe that the results of our immunologic experiments are more convincing of the fallacy of this theory than any other experimental evidence presented before in favor or disfavor of this most unique of all the theore-

tical explanations of immunity that have ever been offered in medicine.

The findings that monkeys infected with syphilis became immune to syphilis much sooner than they did to yaws and that monkeys infected with yaws became immune to yaws sooner than to syphilis prove that the immunologic reciprocity between yaws and syphilis is a group immunity quite similar to group relationship known to exist in bacterial immunity.

Differences may exist between individual strains of treponema of syphilis with regard to cross immunity of heterologous strains, but the significance of these differences appears to have been unduly exaggerated in the literature. No rational explanation of these immunologic peculiarities of individual treponema strains of the same kind is possible as long as the theory of latent infection is accepted as an explanation of resistance to inoculation and the existence of immunity to syphilis is denied. Whatever these variations may be, it cannot be denied that treponema of syphilis and treponema of yaws represent the utmost extremes in this group of parasites. Consequently the immunologic reciprocity between these two proves the existence of pan-treponematous immunity as the highest degree of group immunity.

CONCLUSIONS

1. Immunologic reciprocity exists, not only between yaws and syphilis but also between syphilis and yaws.

2. Syphilis in Philippine monkeys produces immunity to itself much sooner than it does to yaws and sooner than yaws does to itself.

3. Superinoculation with syphilis of syphilitic monkeys performed in the stage of tissue nonreactivity does not hasten the immunity to yaws.

4. Superinoculation of syphilitic monkeys with yaws, performed at a time when they have reached the stage of nonreactivity to syphilis but still react by formation of typical yaw to inoculation with yaws, does not hasten the immunity to yaws within the period tested.

5. The immunologic reciprocity between yaws and syphilis is group immunity. One of the two immunizes against itself quicker than against the other.

TABLE 1.—*Showing the results of cross inoculation with yaws of monkeys that received a single intradermal inoculation with syphilis.*

[+, positive take; —, negative take; 0, not done; D, died. The animals were observed for six months after the last inoculation.]

Designation of monkey.	Inoculated with syphilis.		Lymph-gland transplants (syphilis).		Inoculated with yaws.	
	Date.	Result.	Date.	Result.	Date.	Result.
Sy-E-42	[a] X-27-28	+	0	0	I- 7-29	+
Sy-6	VI-15-28	+	X-22-28	+	IX-11-28	+
Sy-3	VI-13-28	+	IX- 8-28	+	IX-11-28	+
Sy-1	V-16-28	+	IX- 8-28	+	IX-11-28	+
Sy-5	VI-15-28	+	X-22-28	+	XI-13-28	+
Sy-J-20	II- 9-29	+	0	--------	X- 8-29 XII- 2-29	— —
Two controls	0	--------	0	--------	X- 8-29	+ +
Do	0	--------	0	--------	XII- 2-29	+ +

[a] These letters and figures indicate month, day, and year; thus, X-27-28 means October 27, 1928.

TABLE 2.—*Showing the results of experiments concerning immunologic reciprocity between syphilis and yaws.*

[+, positive take; —, negative take; 0, not done; D, died. The animals were observed for six months after the last inoculation.]

Designation of monkey.	Intradermal inoculation with syphilis.					
	Date.	Result.	Date.	Result.	Date.	Result.
Sy-G-20	II- 5-29	+	V-29-29	—	IX-27-29	—
Sy-J-21	II- 9-29	+	V-29-29	—	IX-27-29	—
Sy-J-20	II- 9-29	+	0		0	
Sy-I-11	III-20-29	+	VIII-14-29	—	0	
Sy-I-12	III-20-29	+	VIII-14-29	—	0	
Sy-G-22	VI-22-29	+	VIII-14-29	—	0	
Sy-G-23	VI-22-29	+	VIII-14-29	—	0	
Sy-P-23, control	0		VIII-14-29	+	IX-27-29	—
Sy-P-24, control	0		0		IX-27-29	+
Sy-P-25, control	0		0		IX-27-29	+
Y-G-24, control	0		0		0	
Y-G-25, control	0		0		0	
YM-20, control	0		0		0	
YM-21, control	0		0		0	
YM-22, control	0		0		0	
YM-23, control	0		0		0	
Ya-C-14, control	0		0		0	
Ya-C-15, control	0		0		0	
Ya-C-16, control	0		0		0	

TABLE 2.—*Showing the results of experiments concerning immunologic reciprocity between syphilis and yaws*—Continued.

[+, positive take; —, negative take; 0, not done; D, died. The animals were observed for six months after the last inoculation.]

Designation of monkey.	Intradermal superinfection with yaws.							
	Date.	Result.	Date.	Result.	Date.	Result.	Date.	Result.
Sy-G-20	X- 8-29	—	XII- 2-29	—	0		0	
Sy-J-21	X- 8-29	—	XII- 2-29	D, XII- 9-29	0		0	
Sy-J-20	X- 8-29	—	XII- 2-29	—	0		0	
Sy-I-11	IX-21-29	+	X-21-29	+	I- 6-30	—	II-26-30	—
Sy-I-12	IX-21-29	+	X-21-29	+	I- 6-30	—	D, II-19-30	
Sy-G-22	X-14-29	+	X-21-29	+	I- 6-30	+	II-26-30	—
Sy-G-23	X-14-29	+	X-21-29	+	I- 6-30	D, I-21-30	0	
Sy-P-23, control	X-14-29	+	X-21-29	+	I- 6-30	+	II-26-30	—
Sy-P-24, control	0		0		0		0	
Sy-P-25, control	0		0		0		0	
Y-G-24, control	X- 8-29	+	0		0		0	
Y-G-25, control	X- 8-29	+	0		0		0	
YM-20, control	IX-21-29	+	X-21-29	+	0		0	
YM-21, control	IX-21-29	+	X-21-29	+	0		0	
YM-22, control	X-14-29	+	0		I- 6-30	+	D, I-25-30	
YM-23, control	X-14-29	+	0		0		II-26-30	D, III-4-30
Ya-C-14, control	0		XII- 2-29	+	0		0	
Ya-C-15, control	0		0		I- 6-30	+	II-26-30	+
Ya-C-16, control	0		0		I- 6-30	+	II-26-30	+

THE IMMUNOLOGIC EFFECT OF REPEATED YAWS INFECTIONS INTERRUPTED BY SPECIFIC TREATMENT GIVEN IN THE EARLY STAGE OF INITIAL YAW[1]

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The present experiment was planned in such a way that monkeys inoculated with yaws were treated with neosalvarsan before the third month after the inoculation; that is to say, before the incubation of the generalized manifestations expired. The object of this experiment was to find out whether or not this procedure of repeated inoculations with viable yaws material would produce immunity to yaws when each of the successive local infections were terminated by specific treatment before the time when generalized manifestations appeared.

In previous experiments it became known that Philippine monkeys, which had local yaws infection for three months or more, were found immune in the sixth or seventh month after the inoculation. When yaws monkeys were treated before the third month after the inoculation they were found susceptible to yaws in the seventh month.[2]

THE EXPERIMENT

The first monkey (m–5) was inoculated with yaws in October, 1928. After an incubation of thirty days a lesion developed that assumed the clinical character of a typical yaw forty days after inoculation. Treponemas were found by dark field in the scrapings made from this lesion. Neosalvarsan treatment was given on the fortieth day after inoculation. The lesion healed within a week.

This animal was again inoculated with yaws June 29, 1929; that is, eight months after the original inoculation with yaws.

[1] Presented for publication June 4, 1930.

[2] Philip. Journ. Sci. 35 (1928) 291.

The incubation of the lesion was long, but the lesion was a typical initial yaw and contained treponemas. Consequent to the long incubation, neosalvarsan treatment was not given until the seventy-second day after the second inoculation. The lesion healed rapidly, due to two injections of neosalvarsan. Thirteen days after the last therapeutic injection, and a little less than three months after the second inoculation, the animal was again inoculated; this time simultaneously with four other monkeys, which received a similar course of treatment. The monkey under discussion (m-5) failed to develop a lesion within a month, although its mates developed typical yaws within this period of time. Treatment was given five weeks after this unsuccessful inoculation, and the animal was inoculated the fourth time and developed typical yaw in four weeks. Three months and three weeks later the animal proved to be immune to inoculation with yaws.

In the rest of the animals included in this experiment a somewhat different plan was followed. The reinfections with yaws, interrupted by treatments, were fewer but were given at shorter intervals of time. They received fewer inoculations in rapid succession. Unfortunately, three of the four animals died after the last inoculation; one of them, however, lived long enough to show that the incubation became prolonged. The fourth monkey lived, and two successive tests for immunity were performed. This animal proved to be immune six months three weeks after the original inoculation with yaws.

DISCUSSION

In a previous experiment on six healthy volunteers[3] one behaved irregularly with regard to incubation, but the rest showed very regular incubation upon the first inoculation.

Volunteers A and B developed initial yaws in three and a half weeks; volunteers C, D, and F, four weeks after the inoculation. Volunteers A and B were superinoculated four weeks after the first inoculation, and the incubation of the initial yaw was again three and a half weeks. Volunteers C and D were superinoculated five weeks after the first inoculation and the incubation period was four and a half in one and six weeks in the other volunteer. Volunteer E was superinoculated six weeks after the first inoculation, and local yaw developed in five weeks after the superinoculation.

[3] Sellards, Lacy, and Schöbl, Philip. Journ. Sci. **30** (1926) 463.

All volunteers who were superinoculated more than four weeks after the first inoculation showed a longer period of incubation the second time than they did after the first inoculation. The generalization of the yaws process due to the first inoculation having appeared by that time, the volunteers were treated to the complete clinical and serologic cure and no further inoculation was performed.

In the present experiment on animals very similar conditions were encountered; that is, a prolongation of the incubation periods in the same animals that showed regular incubation in the early inoculations.

The animal (m–5) that received three interrupted inoculations within eleven months was not immune in thirteen months, but was found immune in seventeen months; while K–16 and, very likely, N–20 that received three interrupted inoculations within four months were immune in the seventh month after the original inoculation with yaws. These results agree with our early findings on experimental yaws that brought out the direct quantitative proportions between the severity of early yaws infection and the degree of subsequent immunity, as well as the inverse proportion between the severity of early infection and the time of onset of immunity. The more severe the early infection, the higher the degree of immunity and the earlier it sets in. These results, therefore, agree with the law of inverse proportions as formulated by Brown and Pearce for syphilis, which law in turn is supported by clinical experience. From the point of view of immunization the most opportune time is thereby indicated for the accomplishment of successful immunization. It is evident that the immunization in treponematoses must be fully accomplished during the period of full or even exaggerated tissue reactivity to the incorporation of treponema antigen. This view is further corroborated by our previous findings [4] that superinfection of yaws monkeys with syphilis performed in the early stage of yaws infection accelerated the immunity to yaws, while superinfection with syphilis of syphilitic monkeys performed in the stage of nonreactivity to syphilis had no appreciable accelerating effect on the onset of immunity to yaws.

CONCLUSIONS

1. Repeated local yaws infections terminated by specific treatment given before the time when generalized yaws manifesta-

[4] Philip. Journ. Sci. 42 (1930) 241.

TABLE 1.—*Showing the accumulative immunologic effect of repeated infections interrupted by specific treatment in the early period of yaws infection.*

[+, positive take; —, no take; ?, no take up to the time of treatment; 0, not done; D, died.]

Designation of monkey.	Inoculation.			Neosalvarsan.		Inoculation.			Neosalvarsan.	
	Date.	Result.	Incubation, weeks.	Date.	Gram.	Date.	Result.	Incubation, weeks.	Date.	Gram.
m-5	[a] X-20-28	+	4	XII- 1-28	0.02	VI-29-29	+	6	IX- 1-29 IX- 5-29	0.0115 0.0115
K-16	VIII- 1-29	+	4	IX- 3-29 IX-10-29	0.01125 0.01125	IX-18-29	+	4	X-24-29 X-29-29	0.0115 0.0115
K-17	VIII- 1-29	+	4	IX- 3-29 IX-10-29	0.01125 0.01125	IX-18-29	+	4	X-24-29 X-29-29	0.0115 0.0115
N-20	VIII- 1-29	+	4	IX- 3-29 IX-10-29	0.01125 0.01125	IX-18-29	+	4	X-24-29 X-29-29	0.0115 0.0115
N-21	VIII- 1-29	+	4	IX- 3-29 IX-10-29	0.01125 0.01125	IX-18-29	+	4	X-24-29 X-29-29	0.0115 0.0115
Yac-20, control	0	----	----	0	----	0	----	----	0	----
Do	0	----	----	0	----	0	----	----	0	----
Ya-C-27, control	0	----	----	0	----	0	----	----	0	----

Designation of monkey.	Inoculation.			Neosalvarsan.		Inoculation.			Inoculation.			Confirmatory immunity test.	
	Date.	Result.	Incubation, weeks.	Date.	Gram.	Date.	Result.	Incubation, weeks.	Date.	Result.	Incubation, weeks.	Date.	Result.
m-5	IX-18-29	?		X-24-29	0.015	XI-26-29	+	4	III-15-30	—		V-20-30	—
K-16	XI-26-29	+	4	I-21-30	0.015	0			II-18-30	—		V-20-30	—
K-17	XI-26-29	+	4	I-21-30	0.015	0			II-18-30	?	D, II-25-30	0	
N-20	XI-26-29	+	4	I-21-30	0.015	0			II-18-30	—	D, III-25-30	0	
N-21	XI-26-29	?		I-21-30	0.015	0			II-18-30	?	D, II-25-30	0	
Yac-20, control	0			0		0			II-18-30	+	4	0	
Do	0			0		0			III-15-30	+	4	0	
Ya-C-27, control	0			0		0			0			V-20-30	+

[a] These letters and figures indicate month, day, and year; thus, X-20-28 means October 20, 1928.

tions occur produce immunity in Philippine monkeys, even though delayed.

2. The incubation period becomes irregular, mostly prolonged with the repeated reinoculations terminated by treatments. This shows that the developing immunity, although not yet strong enough to suppress completely the development of lesion, has a definite effect upon the incubation period. This observation strengthens our claim that sensitization is the underlying principle of immunity in treponematoses.

3. The findings made on monkeys corroborate and amplify the findings previously made on human volunteers and prove that immunization against yaws by means of repeated local yaws infections terminated by treatments is possible.

4. Jointly with our previous experimental evidence these results indicate that the most favorable time for immunization in treponematoses is the early stage of infection and that it must be carried out vigorously within the first few months of infection or immunization.

THE DURATION OF ANTITREPONEMATOUS IMMUNITY WITH REGARD TO SYPHILIS IN PHILIPPINE MONKEYS

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In the course of our investigation concerning cross immunity between the two human treponematoses, yaws and syphilis, experimental animals have accumulated that have been inoculated at various times with yaws, with syphilis, or both. In order to utilize these experimental animals to the full extent they were employed in the present experiment. The same animals having been used in previous experiments, the dates concerning the onset of immunity are necessarily given here again. There are two groups of animals represented in Table 1.

The first group contains animals that were inoculated first with yaws, then repeatedly proven immune to yaws and to syphilis. They were tested for immunity to syphilis by intracutaneous inoculation with syphilis (Nichols strain), two and one-half, three and one-half, three and five-sixths, and four and three-fourths years after the original inoculation with yaws. They failed to develop lesions at the place of inoculation. Normal control monkeys inoculated at the same time with the same amount of the same syphilitic material developed typical scleroses.

In the second group were placed monkeys that were originally inoculated with syphilis by intradermal injection. They were then superinoculated with yaws; some while still susceptible, others when already immune to yaws. The final test for immunity to syphilis was performed and properly controlled three, seven, eight, eleven, and nineteen months after the original inoculation with syphilis. They were found immune to intradermal inoculation with syphilis.

TABLE 1.—*Showing the results of experiments concerning the duration of immunity to syphilis produced either by yaws or syphilis infection in Philippine monkeys.*

[+, typical take; —, no take; ±, immune reaction; 0, not done; D, died.]

Designation of monkey.	Inoculated with yaws.		Inoculated with syphilis.		Lymph-gland transplants.		Rabbits.		Test for immunity to syphilis.	
	Date.	Result.	Date.	Result.	Date.	Result.	Lived, V-15-29.	Died.	Date.	Result.
D-18	[a] IV-25-25	+	VI-15-28	±	XI-12-28	—	Two	—	I- 7-30	—
	III-15-26	—								
	V-14-26	—								
	IV- 4-27	—								
	II- 4-28	—								
	I-11-29	—								
J-11	III-19-26	+	IX-13-28	±	XI-16-28	—	One	One II-11-29	I- 7-30	—
	VII- 6-26	+								
	IX-29-26	—								
	IV- 4-27	—								
	III-26-28	—								
	I-11-29	—								
T-4	VII- 2-26	+	IX-13-28	—	XI-16-28	—	—	Two XII- 3-28 XII-10-28	I- 7-30	—
	VIII-20-26	+								
	III- 8-27	—								
	III-26-28	—								
	I- 8-29	—								
o-c	VII-27-26	+	IX-13-28	±	XI-16-28	—	—	Two XII-10-28 XII-12-28	I- 7-30	—
	IV- 4-27	—								
	III-26-28	—								
	I- 8-29	—								

Designation of monkey.	Inoculated with syphilis.		Inoculated with yaws.		Lymph-gland transplants.		Rabbits.		Test for immunity to syphilis.	
	Date.	Result.	Date.	Result.	Date.	Result.	Lived.	Died.	Date.	Result.
Sy-2	V-24-28	(?)	XI-13-28	+	X-22-28	+	One	—	I- 7-30	D
Sy-3	VI-13-28	+	IX-11-28	+	VI-26-28	+	One	—	I- 7-30	—
Sy-5	VI-15-28	+	XI-13-28	+	X-22-28	+	One	—	I- 7-30	—
Sy-G-20	I-29-29 V-25-29	+ —	X- 8-29 XII- 2-29	— —	0				IX-27-29	—
Sy-J-20	II- 9-29	+	X- 8-29 XII- 2-29	— —	0				I- 7-30	—
Sy-J-21	II- 9-29 V-29-29	+ —	X-8-29 XII- 2-29	— D	0				IX-27-29	—
Sy-G-22	VI-22-29 VIII-14-29	+ —	X-14-29 X-21-29 XII- 2-29	+ +	0				IX-27-29	—
Sy-G-23	VI-22-29 VIII-14-29	+ —	X-14-29 X-21-29 XII- 2-29	+ +	0				IX-27-29	—
Sy-P-23, control	VIII-14-29	+								
Sy-P-24, control	0		0		0				IX-27-29	+
Sy-P-25, control	0		0		0				IX-27-29	+
Sy-8, control	0		0		0				I- 7-30	+
Sy-7, control	0		0		0				I- 7-30	+

[a] These letters and figures indicate month, day, and year; thus, IV-25-25 means April 25, 1925.

CONCLUSION

If it is considered that the immunity to syphilis in Philippine monkeys sets in about one and one-half months after the inoculation with syphilis and in about eight months after inoculation with yaws, the persistence of immunity to syphilis in Philippine monkeys is clearly evident. There is every reason to believe that immunity to syphilis, like immunity to yaws, lasts throughout the natural life of these animals.

THE DURATION OF ANTITREPONEMATOUS IMMUNITY IN PHILIPPINE MONKEYS ORIGINALLY CONVEYED BY IMMUNIZATION WITH KILLED YAWS VACCINE

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The purpose of this experiment was to ascertain the duration of immunity to yaws in animals that have been immunized with killed yaws vaccine and stood the test for immunity repeatedly, both to yaws and syphilis.[1]

Four animals survived the previous experiment up to date. They had been vaccinated in the latter part of 1927 and the early part of 1928. The ultimate test for the duration of immunity was performed in February, 1930. This test consisted of intradermal inoculation with viable yaws material. The viability of the inoculum was tested simultaneously on one normal control Philippine monkey. The interval of time between the first vaccination and the last test for immunity to yaws varies, therefore, from two to two and a half years. Following the vaccination and the early test for immunity to yaws by inoculation, the animals were tested for immunity to syphilis by inoculation with live syphilitic material. They were found immune to syphilis as far as the skin is concerned, although the treponemas of syphilis were found viable in the lymph glands corresponding to the point of inoculation with syphilis.

The immunity, the duration of which was tested in this experiment, is not the result of vaccination alone. The animals were inoculated with yaws and syphilis subsequent to the vaccination. Some of them, however, showed no specific lesion from the time of vaccination up to the last test for immunity. The condition with regard to infection was, therefore, different from the condition in the inoculated monkeys that developed

[1] Philip. Journ. Sci. 42 (1930) 219.

lesion and in which the duration of immunity was previously tested.[2]

There is little doubt that inoculation following vaccination increases the antitreponematous immunity. It is known that inoculation with yaws performed on vaccinated animals raises the serologic reactions in experimental animals.[3]

The close relation between the serologic response to infection and the onset of immunity has likewise been demonstrated.[4]

Furthermore, it has become known that superinfection with syphilis performed on yaws-infected monkeys, in the stage of tissue reactivity to syphilis, accelerates the development of immunity to yaws.[5]

On the other hand superinfection with syphilis performed on syphilitic monkeys in the stage in which the skin no longer reacts to the inoculation did not accelerate noticeably the immunity to yaws.[6]

It was, therefore, important to ascertain the duration of the antitreponematous immunity acquired under these conditions. The attached table gives the results of this experiment and shows that the immunity is of long duration.

CONCLUSIONS

Antitreponematous immunity in vaccinated monkeys that have been proven immune to skin inoculation with yaws and syphilis is of as long duration as the immunity induced by infection accompanied by specific skin lesion.

[2] Philip. Journ. Sci. 40 (1929) 49.
[3] Philip. Journ. Sci. 40 (1929) 61.
[4] Philip. Journ. Sci. 42 (1930) 203.
[5] Ibidem 241.
[6] Antea 583.

TABLE 1.—*Showing the results of test for duration of antitreponematous immunity performed on yaws-vaccinated Philippine monkeys.*

[+, lesion; —, no lesion; 0, not done. All normal control animals employed in the tests for immunity to yaws or to syphilis developed typical lesions.]

Designation of monkey.	Date of vaccination.			Date of test for yaws immunity.			Result.	Date of test for syphilis immunity.	Result.		Date of last test for yaws immunity.	Result.
									Lesion.	Glands.		
U-1	[a] VII-27-27	VII-30-27	VIII-3-27	IX-17-27	III- 9-28	IV-23-28	—	I-7-29	—	0	II-14-30	—
W-23	I-18-28	I-31-28	II-8-28	II-27-28	IV-23-28	VI- 4-28	—	I-7-29	—	+	II-14-30	—
W-25	I-20-28	I-31-28	0	II-27-28	V- 3-28	VI-25-28	—	I-7-29	—	+	II-14-30	—
W-27	I-20-28	I-31-28	0	II-27-28	V- 3-28	VI-25-28	—	I-7-29	—	0	II-14-30	—
Control, Ya-C-19	0	0	0	0	0	0	....	0	....	....	II-14-30	+

[a] These letters and figures indicate month, day, and year; thus, VII-27-27 means July 27, 1927.

THE IMMUNOLOGIC EFFECT OF ANTITREPONEMATOUS VACCINE THERAPY ADMINISTERED AFTER SPECIFIC TREATMENT WHICH WAS GIVEN IN THE EARLY STAGE OF INITIAL LOCAL YAWS IN PHILIPPINE MONKEYS

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ONE TEXT FIGURE

In order to test the possibilities of the beneficial effect that vaccination may have on the course of treponematous infections, the following experiment was carried out.

Four Philippine monkeys were inoculated with yaws on the eyebrows by intradermal injection. All of these animals showed early serologic response following the inoculation with yaws (text fig. 1). Three monkeys developed typical clinical yaws containing treponemas. One of the four monkeys (K–27) failed to develop clinical yaws up to the time when treatment was given but showed, like others, distinct early serologic response to the inoculation. Due to the failure on the part of this animal to develop a clinical lesion within seven weeks after the first inoculation with yaws, this animal was kept as one of the non-vaccinated yaws-control animals.

The original inoculation with yaws of the four monkeys was performed November 27, 1929, and neosalvarsan treatment was given January 21, 1930, and again January 27, 1930, the total amount of the drug given to each monkey by intramuscular injection being 0.03 grams. The yaws lesions healed within a week after the first injection of neosalvarsan. Following this treatment, monkeys K–25 and K–26 were given three subcutaneous injections of syphilis vaccine, heated at 60° C. for one hour, on February 13, February 25, and March 4, 1930. The other two of the four monkeys, K–27 and K–28, received no vaccination and were kept as non-vaccinated yaws controls.

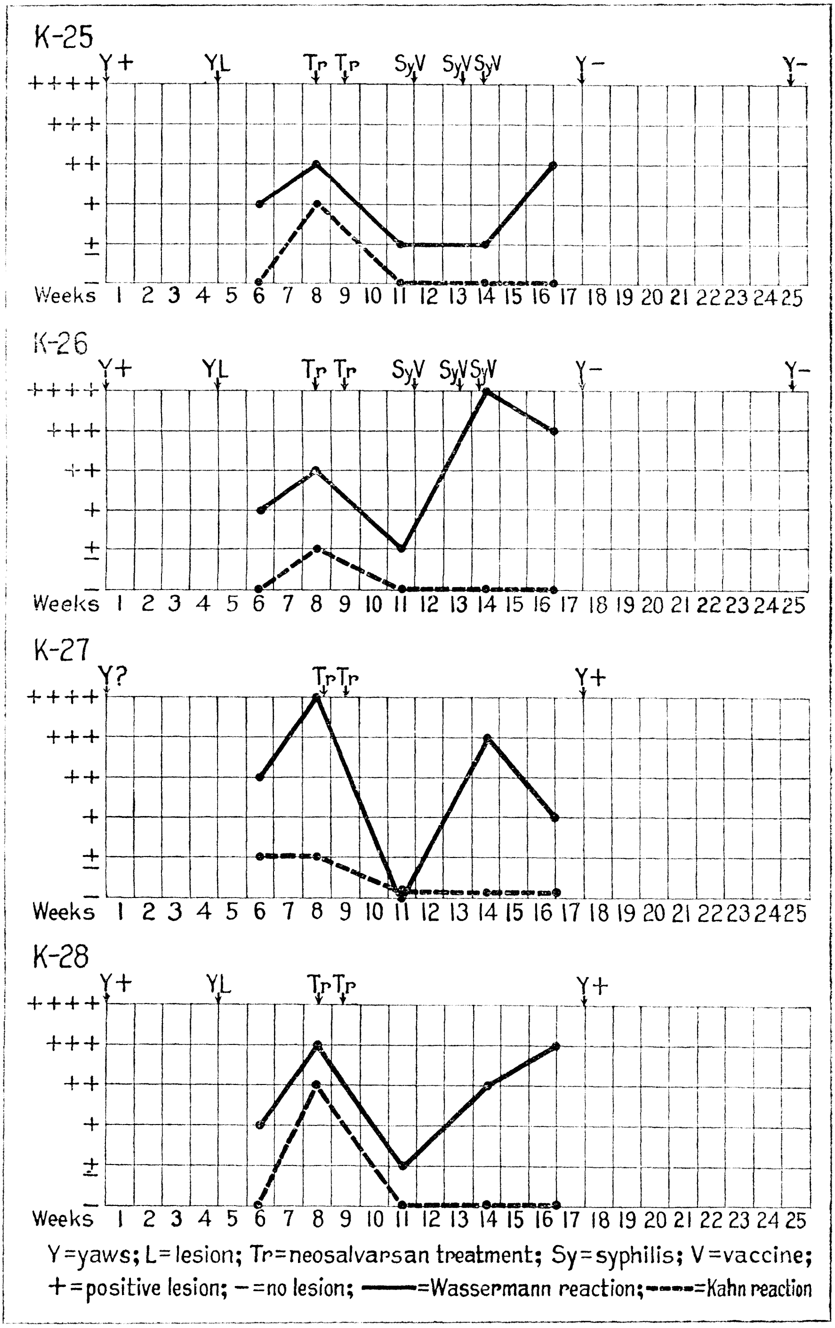

FIG. 1. Showing the serologic and immunologic effect of antitreponematous vaccine therapy given to yaws monkeys cured by neosalvarsan in the early stage of initial local yaws. The serologic reactions were kindly performed by Dr. Onofre Garcia, of the division of biology and serum laboratory, Bureau of Science, and were read jointly by him and the author.

The test for immunity was performed on these four monkeys by intradermal inoculation with viable yaws material on March 27, 1930; that is, four months after the original inoculation with yaws. Simultaneously with these monkeys a normal control monkey was inoculated in the same manner with the same amount of the same yaws inoculum.

Following the second inoculation with yaws as a test for immunity, the animals were inspected at frequent intervals and the following was found:

April 16, 1930, less than three weeks after the last inoculation, small oozing papular efflorescences were found at the places of inoculation on the eyebrows of the normal control monkey Ya–C–24 and the non-vaccinated yaws monkey K–28. These papules developed into typical yaws and contained treponemas.

April 23 a typical oozing papular lesion was found in the second non-vaccinated yaws monkey, K–27. This animal, it will be remembered, failed to develop a lesion upon first inoculation with yaws, within the time of seven weeks allowed to elapse between the inoculation and the specific treatment. Even though the yaws lesion that developed in this animal on the second inoculation healed rapidly, it had the typical clinical character and contained treponemas. Therefore, this animal was not immune at the time the second inoculation with yaws was performed as a test for immunity.

The two treated, and subsequently vaccinated, monkeys K–25 and K–26, showed a slight swelling at the place of the second inoculation in about two weeks, but no lesion developed. A confirmatory test for immunity was made on these two last-mentioned animals May 20, 1930. Simultaneously, one normal control monkey was inoculated with the same inoculum and in the same manner as the two vaccinated yaws monkeys. This test confirmed the previous test for immunity.

SUMMARY AND DISCUSSION

Four Philippine monkeys were inoculated with Kadangan strain of yaws and treated with neosalvarsan seven weeks after the inoculation; that is, in the early stage of the initial local yaw. Two of these four animals were vaccinated with killed syphilis vaccine (Nichols strain) subsequent to the chemotherapeutic cure. Test for immunity by inoculation with yaws, performed four months after the original inoculation, showed that the treated and vaccinated yaws monkeys were immune in four

months after the original inoculation, while the treated non-vaccinated yaws monkeys were not immune at that time. It is evident from this time relation that immunity in early treated and vaccinated yaws monkeys sets in just as soon after the vaccination as it does after generalization of the yaws process in untreated yaws infected animals.[1]

The great significance of the findings that vaccine treatment, administered to infected animals that were treated in the early stage of initial lesion, accelerates the onset of immunity will at once be realized when the law of inverse proportions, as formulated by Brown and Pearce for syphilis, is recalled to mind.

Although this law does not apply to yaws in the same manner that it applies in syphilis, it holds true in a general way. The more extensive and intensive the early yaws lesions, either initial or generalized, the less pronounced will be the late ulcerative or hyperkeratotic lesions. Monkeys with intensive exacerbations of initial yaws, followed by generalized eruptions, failed to develop late yaws lesions. On the other hand, animals that developed late lesions exhibited mild initial yaw and no generalized dissemination of lesions.

It became known from our early experiments on immunity to yaws that in animals with generalized yaws, so called secondaries, or in monkeys with late yaws lesions, so called tertiaries, no new lesions appeared once these animals became immune to inoculation. Thus, the effect of immunity upon the course of the infection was experimentally demonstrated. Furthermore, the case published from our institution by Miyao, indicates the effect of immunity on the course of yaws infection.[2]

A normal monkey was inoculated with Kadangan strain of yaws. It was treated with neosalvarsan less than three months after the inoculation. The lesions healed rapidly. One year after the treatment, the monkey was inoculated again with yaws. After long incubation an unusually late, fungoid, and ulcerative yaws lesion developed in this monkey. This shows that immunity was not fully developed in this animal at the time of reinfection with yaws and a late, so called tertiary lesion developed in consequence of reinfection.

[1] Philip. Journ. Sci. 35 (1928) 286.
[2] Philip. Journ. Sci. 41 (1930).

In the present experiment the early treated and vaccinated monkeys developed immunity in six weeks after the vaccination to such a degree that reinfection and consequently further stages of the infection were prevented. Thus, it was proven that antitreponematous vaccine therapy of an infected and early treated host has a beneficial effect on the course of the treponematous infection. The vaccine therapy under such conditions prevents not only reinfection of the host but also the occurrence of late lesions which are the most tragic features of treponematoses as illustrated in our early study on yaws in Philippine monkeys.[3]

CONCLUSIONS

1. Vaccine therapy with killed syphilis vaccine performed on yaws-infected and early treated monkeys accelerates the onset of immunity to yaws.
2. The immunity to yaws as a consequence of syphilis vaccine treatment administered to early cured yaws monkeys develops earlier than it does in early cured non-vaccinated yaws monkeys and earlier than it develops in untreated yaws monkeys with local yaws only.
3. The immunity under the conditions of vaccine treatment just mentioned, develops as early after the vaccination as it does in yaws-infected untreated monkeys after the generalization of the yaws process.
4. These findings are further proof of immunologic reciprocity between yaws and syphilis[4] and corroborate our previous findings that superinfection with syphilis of yaws-infected monkeys accelerates immunity to yaws.[5]
5. This experiment proves our contention deduced from former experiments[6] that vaccination administered early to recently sensitized animals has the same immunologic effect as generalization of the treponematous process. It confirms our former findings concerning vaccination in treponematoses.

[3] Philip. Journ. Sci. 35 (1928) pls. 18, 19, 20, 22, 23, and 24.
[4] Philip. Jour. Sci. 40 (1929) 91; 43 (1930) 263, 583.
[5] Philip. Journ. Sci. 42 (1930) 241.
[6] Philip. Journ. Sci. 42 (1930) 219.

TABLE 1.—*Showing the immunologic effect of antitreponematous vaccine therapy administered to yaws monkeys treated with neosalvarsan in the early stage of initial local lesion.*

[+, positive lesion; —, no lesion; ?, no lesion up to treatment; 0, not done. The animals were kept under observation six months after the last test for immunity.]

Designation of monkey.	Inoculation with yaws.		Neosalvarsan treatment.		Syphilis vaccine.
	Date.	Result.	Date.	Grams.	Date.
K-25	[a] XI-27-29	+	I-21-30	0.03	II-13-30
K-26	XI-27-29	+	I-21-30	0.03	II-13-30
K-27	XI-27-29	?	I-21-30	0.03	0
K-28	XI-27-29	+	I-21-30	0.03	0
Control	0	--------	0	--------	0
Do	0	--------	0	--------	0

Designation of monkey.	Tests for immunity by inoculation with yaws.			
	Date.	Result.	Date.	Result.
K-25	III-27-30	—	V-20-30	—
K-26	III-27-30	—	V-20-30	—
K-27	III-27-30	+	0	--------
K-28	III-27-30	+	0	--------
Control	III-27-30	+	0	--------
Do	0	--------	V-20-30	+

[a] These letters and figures indicate month, day, and year; thus XI-27-29 means November 27, 1929.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Showing the serologic and immunologic effect of antitreponematous vaccine therapy given to yaws monkeys cured by neosalvarsan in the early stage of initial local yaws. The serologic reactions were kindly performed by Dr. Onofre Garcia, of the division of biology and serum laboratory, Bureau of Science, and were read jointly by him and the author.

THE USE OF TETANUS ANATOXIN IN THE PROTECTION OF HORSES AGAINST INFECTION BY CHLOSTRIDIUM TETANI [1]

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Tetanus is not an uncommon disease among horses and mules in the United States Army, particularly in tropical countries. While the prevalence is not great enough to be considered alarming, the possibility of losing animals from tetanus, especially during military expeditions or periods of emergency, is of sufficient importance to make the development of some method of prophylactic immunization desirable. Consequently, experiments have been performed to determine whether horses can be "vaccinated" against tetanus with preparations of detoxified tetanus toxin, or "anatoxin," prepared according to the method of Ramon.(1)

The work of Ramon with his "anatoxins" suggested that this product might be used in a practical manner for immunization of large animals against tetanus. He states that it was formerly believed that in order to produce a lasting immunity in animals it was necessary to use an unmodified toxin for inoculation, but in contrast to this claim he has demonstrated that the injection of a toxin, particularly diphtheria toxin so modified that it is innocuous not only produces immunity but brings about a rapid and abundant production of antitoxin. In referring to the discovery of diphtheria "anatoxin" Ramon states that originally a small quantity of formaldehyde was added to the diph-

[1] From the United States Army Medical Department Research Board, Bureau of Science, Manila, Philippine Islands.

theria toxin for the purpose of preventing bacterial contamination, but that after several months it was noticed that toxicity gradually decreased while other features of this toxin remained. This led him and his associates to augment the quantity of formaldehyde to three or four parts of formalin per thousand of toxin. He stated that treating thus a toxin $\frac{1}{800}$ of 1 cubic centimeter of which originally killed a 300-gram guinea pig in four days, they obtained, after one month a product 10 cubic centimeters of which produced no symptoms whatever in a guinea pig. Further, he stated that 1 cubic centimeter of this product, injected into a guinea pig, produced sufficient immunity after eighteen days to prevent death after the injection of several times a fatal dose of toxin, and after one month the animal was immune to from fifty to one hundred fatal doses. If two injections of 1 cubic centimeter each were made at intervals of three weeks, the animals were able to resist one thousand or more fatal doses after the last injection. Thus, the toxin after losing its toxicity, still retained its antigenic properties. Ramon calls attention to the fact that this method applies equally as well to the detoxication of tetanus toxin, and reported that experimental animals, which were inoculated with this product, were unaffected by the subsequent injection of lethal amounts of tetanus toxin.

In naturally acquired infections the tetanus spores are usually dry and probably contain little or no toxin. The spores alone would probably fail to cause infection were it not for the additional presence of pyogenic bacteria, as for instance staphylococci which produce a leukocidin and by its action on the leukocytes prevents destruction of the spores which then vegetate, multiply, and elaborate toxin.

It has been found to be practically impossible to remove toxin from spores in broth culture except by heating at 68° C. for five minutes. This simple procedure destroys toxin without causing death of the spores. Francis(3) states that washing of tetanus spores by successive suspensions in large quantities of salt solutions does not rid them of their toxin, but that heating of the spores at 80° C. for one hour renders them free from toxin, without impairing their infectivity. He further states that when toxin-free spores are injected into guinea pigs, tetanus does not result, but if quinine or staphylococci be injected simultaneously with the spores, tetanus and death follow promptly and regularly in from three to six days. He quotes

Semple, who stated that "when tetanus spores are carefully prepared and free from any trace of toxin or contamination of any kind they may be injected into susceptible animals without producing tetanus. Its success depends upon the fact that the phagocytes can pick up and digest tetanus spores in the absence of any irritant or other material likely to distract them, but when virulent spores mixed with toxin, other bacteria or other spores, sterile powdered charcoal, sterile sand, quinine, lactic acid, or anything which keeps away phagocytes, or occupies their attention, are injected hypodermically into susceptible animals, such as guinea pigs or monkeys, tetanus is the result."

The fact that recovery from infection usually does not confer immunity and that animals may be repeatedly reinfected have necessitated the frequent use of tetanus antitoxin when indicated.

According to Hutyra and Marek,(2) the horse possesses the greatest susceptibility for the virulent living cultures and toxin, and is followed by the guinea pig, goat, sheep, mouse, and rabbit. These authors state that "one cubic centimeter of the filtrate of a highly virulent culture kills a horse 500 Kgms. in weight; 0.001 cubic centimeter kills a guinea pig of 300 grams while other species of animals require proportionately larger doses of toxin. If for 1 gram of body weight of the horse the lethal dose is 1, guinea pigs require 2, goats 4, mice 13, rabbits 2,000, chickens 200,000 doses per gram of weight (Knorr)."

EXPERIMENTAL

In preparing the anatoxin, all the essentials of Ramon's method were followed. The technic is simple and merely involves the adding of three parts of commercial formalin to one thousand parts of liquid tetanus toxin followed by incubation at 37.5° C. for thirty days.

It was our desire to ascertain whether tetanus anatoxin would develop a sufficiently strong, active immunity to protect against infection with spores together with dirt or other foreign material such as is usually found in cases of natural origin.

IMMUNIZATION OF GUINEA PIGS WITH LIQUID TETANUS ANATOXIN LOT A

Experiment 1.—Lot "A" anatoxin was prepared from a toxin 0.0004 cubic centimeter of which killed a 350-gram guinea pig within three days. Three parts of commercial formalin per thousand of toxin were added, and the product was incubated

at 37.5° C. for thirty days. This was then injected into three guinea pigs as shown in Table 1.

From Table 1 it will be seen that three guinea pigs remained normal for over one month following injections of anatoxin in amounts which, before treatment with formalin, represented 5,000, 10,000, and 15,000 minimal lethal doses of tetanus toxin. A high degree of immunity was shown by these animals when at the end of one month they were tested by the inoculation of washed tetanus spores combined with unsterilized garden soil and *Staphylococcus albus*. In order to simulate natural infection a splinter dipped into the infective material was inserted in the site of inoculation. The control guinea pig (No. 4) developed tetanus on the day after injection and was destroyed on the second day. The vaccinated guinea pigs remained normal during an observation period of one month, after which they were discarded.

TABLE 1.—*Immunization of guinea pigs with liquid tetanus anatoxin Lot "A."*

Guinea pig No.	Tetanus anatoxin injected; November 23, 1928.		Observation from November 23 to December 28, 1928.	Inoculated with lethal amounts of washed spores, etc.	Observation period for one month.		
	Amount.	Minimal lethal doses prior to detoxication.			Dec. 30.	Dec. 31.	Jan. 28, 1929.
	cc.						
1	2.0	5,000	Normal	Dec. 29, 1928	Normal	Normal	Normal.
2	4.0	10,000	do	Dec. 29, 1928	do	do	Do.
3	6.0	15,000	do	Dec. 29, 1928	do	do	Do.
4	0.0	0		Dec. 29, 1928	Tetanus	Destroyed	

IMMUNIZATION OF GUINEA PIGS WITH DRIED TETANUS ANATOXIN LOT C

Experiment 2.—Lot "C" anatoxin was prepared in a similar manner to Lot "A." Minimal lethal dose of the toxin, prior to treatment, was 0.0004 cubic centimeter.

It was desired to ascertain if precipitated, desiccated, and powdered anatoxin would immunize animals as well as the liquid anatoxin. Therefore, 400 cubic centimeters of Lot "C" were saturated with ammonium sulphate, after which the precipitate was collected in an evaporating dish and worked with a spatula until all the solution had been removed. To the resulting gum-

my precipitate was added 6 grams of lactose; the mass was molded into a small pellet, and placed in vacuo in a desiccator over sulphuric acid. Six days later the dried anatoxin was removed and ground to a fine powder, of which the weight was 7.668 grams. As the 400 cubic centimeters of liquid anatoxin contained 1,000,000 detoxified minimal lethal doses of toxin and as there was a loss of approximately 25 per cent in handling, the 7.668 grams of powder represented approximately 750,000 detoxified minimal lethal doses and, accordingly, 1 gram represented about 97,809 detoxicated minimal lethal doses.

A portion of the powder was dissolved in sterile distilled water, and different amounts were injected into guinea pigs as shown in Table 2.

TABLE 2.—*Guinea-pig test of dried tetanus anatoxin Lot "C."*

Guinea pig No.	Tetanus anatoxin injected, March 25, 1929. Amount.	Tetanus anatoxin injected, March 25, 1929. Minimal lethal doses prior to detoxication.	Observation from March 25 to April 23, 1929.	Inoculated with lethal amounts of washed spores, etc.	Observation period. April 24.	Observation period. April 25.
	g.					
1	0.062	6,063	Dead [a]			
2	0.125	12,225	Normal	April 23, 1929	Tetanus	Dead.
3	0.250	24,450	do	April 23, 1929	do	Do.
4	0.500	48,900	do	April 23, 1929	do	Do.
5	0.0	0		April 23, 1929	Dead	
6	0.0	0		April 23, 1929	do	

[a] Cause undetermined.

One month later the guinea pigs were inoculated with tetanus spores in a manner similar to that followed in experiment 1. There were approximately 100,000 spores per cubic centimeter. All of the animals died two days later.

Comment.—From this experiment it appears that desiccated anatoxin, as prepared in this manner, possesses no immunizing properties. The "vaccinated" guinea pigs lived but one day longer than the controls.

Experiment 3.—Immunization of guinea pigs with dried tetanus anatoxin (Lots A and C).

One hundred cubic centimeters of liquid anatoxin "A" was saturated with ammonium sulphate and handled exactly as in the case of Lot "C" except that lactose was not added prior to desiccation.

Lot "A" possessed a minimal lethal dose of 0.0004 cubic centimeter and 100 cubic centimeters yielded 0.530 gram of powder; allowing for about 25 per cent loss in preparation, the 0.530 gram of powder should have contained approximately 187,500 detoxicated minimal lethal doses.

Desiccated Lot "A," without the addition of lactose, and desiccated Lot "C," which had been combined with lactose, were tested for immunizing properties by the injection of six guinea pigs. The results are set forth in Table 3.

One month after the injections with anatoxin these guinea pigs were inoculated with tetanus spores in a similar manner to the other lots, except that the spores were heated to 68° C. for five minutes to destroy any toxin present.

It is apparent from these results that the anatoxin was either lost during the precipitation and drying or was so modified that it was no longer capable of immunizing the animals tested.

IMMUNIZATION OF GUINEA PIGS WITH LIQUID TETANUS ANATOXIN LOT D

Experiment 4.—This lot of anatoxin was prepared from a toxin the minimal lethal dose of which was 0.0005 cubic centimeter. It was tested in the same manner as Lot "A."

It will be seen from Table 4 that while Lot "D" possessed some immunizing power, a dose of 4 cubic centimeters was necessary to prevent infection.

IMMUNIZATION OF HORSES AND MULES WITH LIQUID TETANUS ANATOXIN LOT A

Experiment 5.—The experimental results proving that guinea pigs were protected from infection with tetanus by anatoxin led to a similar investigation of the practical value of this agent in the immunization of larger animals, particularly horses and mules.

Nine animals at Fort William McKinley were, therefore, selected and injected subcutaneously with different doses of Lot "A" anatoxin. Three animals, Nos. 1, 4, and 7, were tested for immunity after the lapse of one month; three, Nos. 2, 5, and 8, after six months; and Nos. 1, 5, 6, and 7 after one year. With three exceptions all animals received a single dose of anatoxin; animals 7, 8, and 9 were given an additional injection thirty days after the first. Table 5 shows the results of the protection given by anatoxin in each of the animals used.

TABLE 3.—*Guinea-pig test of dried tetanus anatoxin Lots "A" and "C."*

LOT "A" (WITHOUT LACTOSE).

Guinea pig No.	Tetanus anatoxin injected May 2, 1929. Amount.	Tetanus anatoxin injected May 2, 1929. Minimal lethal doses prior to detoxication.	Observation from May 2 to June 3, 1929.	Inoculated with lethal amounts of heated spores, etc.	Observation period. June 5.	June 6.	June 7.	June 8.	June 9.
	g.								
1	0.050	17,700	Normal	June 4, 1929	Stiff leg	Tetanus	Tetanus	Tetanus	Dead.
2	0.100	35,400	do	June 4, 1929	do	do	do	Dead	
3	0.200	70,800	Dead [a]						
LOT "C" (WITH LACTOSE).									
4	0.125	12,225	Normal	June 4, 1929	Stiff leg	Tetanus	Tetanus	Dead	
5	0.250	24,450	do	June 4, 1929	do	do	do	do	
6	0.500	48,900	Dead [a]						
7	0.0	0		June 4, 1929	Tetanus	Dead			
8	0.0	0		June 4, 1929	do	do			

[a] These two guinea pigs had markedly inflamed adrenals and other signs of toxæmia.

TABLE 4.—*Immunization of guinea pigs with liquid tetanus anatoxin Lot "D."*

Guinea pig No.	Tetanus anatoxin injected; June 17, 1929.		Observation from June 17 to July 19, 1929.	Inoculated with lethal amounts of washed spores, etc.	Observation period.				
	Amount.	Minimal lethal doses prior to detoxication.			July 20.	July 21.	July 22.	July 23.	July 28.
	cc.								
1	2	4,000	Normal	July 19, 1929	Stiff leg	Stiff leg	Stiff leg	Tetanus (destroyed)	
2	4	8,000	do	July 19, 1929	do	do	do	Normal	Discarded.
3	6	12,000	do	July 19, 1929	do	do	do	do	Do.
4	0	0		July 19, 1929	do	Tetanus	Dead		
5	0	0		([a])	do	Normal	Normal	Normal	Discarded.

[a] Garden soil only.

TABLE 5.—*Immunization of horses and mules with anatoxin Lot "A."*

Animal No.	Brand.	Tetanus anatoxin Lot "A."				Inoculated with spores, etc.	Results.	
		Date.	Amount injected.	Date.	Amount injected.			
			cc.		*cc.*			
1	[a] 211W			Feb. 4, 1929	10	Mar. 9, 1929 Mar. 19, 1930 Mar. 31, 1930		Normal.
2	462W			Feb. 4, 1929	10	Aug. 22, 1929	Tetanus	Dead.
3	[b] 02V8			Feb. 4, 1929	10	([c])		
4	122W			Feb. 4, 1929	20	Mar. 9, 1929	Tetanus	Dead.
5	087W			Feb. 4, 1929	20	Aug. 22, 1929 Aug. 19, 1930 Aug. 31, 1930		Normal.
6	006W			Feb. 4, 1929	20	Mar. 19, 1930 Mar. 31, 1930		Do.
7	22V0	Jan. 14, 1929	15	Feb. 4, 1929	15	Mar. 9, 1929 Mar. 19, 1930 Mar. 31, 1930		Do.
8	[b] 01V5	Jan. 14, 1929	15	Feb. 4, 1929	15	([c])		
9	19V8	Jan. 14, 1929	15	Feb. 4, 1929	15	Aug. 22, 1929	Tetanus	Dead.

[a] "W" indicates a mule; all others are horses. [b] Animals destroyed for other reasons prior to the time set for the immunity test. [c] Not tested.

Animals 3 (02V8) and 8 (01V5), Table 5, were unfortunately ordered destroyed for other reasons prior to the time set for the immunity test. However, as shown in Tables 6, 7, and 8, substitutes were obtained later.

The first group of animals was tested one month after the administration of anatoxin (Table 6), animals 1 (211W) and 7 (22V0) showed no ill effects at any time during the test, and although No. 4 (122W) died, death did not occur until seventeen days following infection, while the two control animals died in five days.

The method of infecting these animals was far more severe than would probably occur in nature. The spores, about 77,000,000 to the cubic centimeter, were not heated, but washed twice with physiological salt solution, and contained preformed toxin. Spores mixed with a fresh suspension of *Staphylococcus albus* and fresh earth were injected into a subcutaneous tract previously made with a trocar. This was followed by the insertion of a splinter, which had been dipped into the mixture.

The results obtained with animals of the second group, tested six months after having received anatoxin, are shown in Table 7.

Mule 5 (087W) developed slight symptoms of tetanus August 30, eight days subsequent to infection, but was improved the following day and normal September 10. No. 2 (462W) showed symptoms August 26, four days after infection, and was destroyed on the 29th, seven days after infection. Horse 8 (19V8) showed symptoms August 30, eight days subsequent to infection, and was destroyed August 31, nine days after infection.

Both controls showed symptoms several days before the vaccinated animals; symptoms were pronounced in the controls on the 28th and 29th and they were destroyed.

The only differences between this test and that of March 9 (Table 6) were the length of time between vaccination and infection, and the number of spores injected. In the first group the test was made thirty-three days after vaccination, and 77,000,000 spores per cubic centimeter were injected, while in the second group, the test was made six months after vaccination and 200,000,000 spores per cubic centimeter were inoculated.

The following test of the third group, which took place one year subsequent to vaccination (February, 1929), included four animals, three of which had been tested for immunity on previous dates. These animals (Table 8) included all that re-

TABLE 6.—*Immunization of horses and mules with tetanus anatoxin Lot "A."*

[Tested one month after the last date anatoxin was administered.]

No.[a]	Brand.	Tetanus anatoxin Lot "A."				Inoculated with washed spores, etc.	Results.	
		Date.	Amount injected.	Date.	Amount injected.			
			cc.		*cc.*			
1	211W			Feb. 4, 1929	10	Mar. 9, 1929	No symptoms	Normal.
4	122W			Feb. 4, 1929	20	Mar. 9, 1929	Mar. 20, tetanus	Mar. 26, dead.
7	22V0	Jan. 14, 1929	15	Feb. 4, 1929	15	Mar. 9, 1929	No symptoms	Normal.
Control	141W					Mar. 9, 1929	Mar. 11, tetanus	Mar. 14, dead.
Do	9V96					Mar. 9, 1929	do	Do.

[a] See numbers in Table 5.

TABLE 7.—*Immunization of horses and mules with tetanus anatoxin Lot "A."*

[Tested six months after the last date anatoxin was administered.]

No. [a]	Brand.	Tetanus anatoxin Lot "A."				Inoculated with washed spores, etc.	Results.	
		Date.	Amount injected.	Date.	Amount injected.			
			cc.		*cc.*			
2	462W			Feb. 4, 1929	10	Aug. 22, 1929	Aug. 26, tetanus	Aug. 29, destroyed.
5	087W			Feb. 4, 1929	20	Aug. 22, 1929	Aug. 30, slight symptoms Aug. 31, normal Sept. 10, normal	Normal.
8	19V8	Jan. 14, 1929	15	Feb. 4, 1929	15	Aug. 22, 1929	Aug. 30, tetanus	Aug. 31, destroyed.
Control	022W					Aug. 22, 1929	Aug. 23, stiff gait Aug. 24, tetanus Aug. 29, marked tetanus	Aug. 29, destroyed.
Do	8V91					Aug. 22, 1929	Aug. 24, stiff gait Aug. 26, tetanus Aug. 28, marked tetanus	Aug. 28, destroyed.

[a] See numbers on Table 3.

TABLE 8.—*Immunization of horses and mules with tetanus anatoxin Lot "A."*

[Tested one year after last date anatoxin was administered.]

No.	Brand.	Anatoxin Lot "A."				Inoculated with washed spores, etc.	
		Date.	Amount injected.	Date.	Amount injected.	Date.	Result.
			cc.		*cc.*		
1	211W			Feb. 4, 1929	10	Mar. 9, 1929	Normal.
5	087W			Feb. 4, 1929	20	Aug. 22, 1929	Do.
6	006W			Feb. 4, 1929	20		
7	22V0	Jan. 4, 1929	15	Feb. 4, 1929	15	Mar. 9, 1929	Normal.
Control	47V6						

No.	Inoculated with heated spores, etc. [a]	Observation.		Inoculated with washed spores, etc.	Observation.		
		March 29.	March 30.		April 1.	April 2.	April 20.
1	Mar. 19, 1930	Normal	Normal	Mar. 31, 1930	Normal	Normal	Normal.
5	Mar. 19, 1930	do	do	Mar. 31, 1930	do	do	Do.
6	Mar. 19, 1930	do	do	Mar. 31, 1930	do	do	Do.
7	Mar. 19, 1930	Symptoms	do	Mar. 31, 1930	do	do	Do.
Control	Mar. 19, 1930	do	Tetanus [b]	Mar. 31, 1930	Tetanus	Marked tetanus; destroyed	

[a] March 19, 1930, spore culture heated at 68° C. for six minutes.
[b] Stiff gait, head, neck, and tail extended; reaction of nictitans membrane when head is elevated.

mained from the nine vaccinated one year previously. Two were previously destroyed because of a respiratory affection and were never subjected to an immunity test; therefore, the comparison should be made with seven rather than nine animals.

Three of the seven animals considered, Nos. 2, 4, and 8, showed no evidence of protection when *C. tetani* was injected. One year later the four remaining animals were again tested with the following results.

Animal 1 (211W) was injected with tetanus spores March 9, 1929; March 19, 1930; and again March 31, 1930, and survived.

Animal 5 (087W) was inoculated with tetanus spores August 22, 1929; March 19, 1930; and March 31, 1930, and remained normal.

Animal 6 (006W) was inoculated with tetanus spores March 19, 1930, and March 31, 1930, and remained normal.

Animal 7 (22V0) was inoculated with tetanus spores March 9, 1929; March 19, 1930; and March 31, 1930; and while it showed some slight symptoms March 28 and 29, it was normal on the 30th and on the 31st when it was again inoculated with *C. tetani.* It remained normal.

Experiment 2.—A second experiment, embracing seven vaccinated animals and one control, gave surprisingly different results, as none of these animals developed an immunity to tetanus following the administration of anatoxin (Table 9).

TABLE 9.—*Test of immunization of horses with tetanus anatoxin Lot "D."*

[Tested five and one-half months after anatoxin was administered.]

No.	Brand.	Tetanus anatoxin Lot "D." Date.	Tetanus anatoxin Lot "D." Amount injected.	Inoculated with washed spores, etc.	Results.	
			cc.			
1	H501	Oct. 24, 1929	25	Apr. 8, 1930	Tetanus	Destroyed, Apr. 15.
2	2V28	Oct. 24, 1929	25	Apr. 8, 1930	do	Destroyed, Apr. 17.
3	2V38	Oct. 24, 1929	25	Apr. 8, 1930	do	Destroyed, Apr. 16.
4	0307	Oct. 24, 1929	30	Apr. 8, 1930	do	Destroyed, Apr. 17.
5	2V61	Oct. 24, 1929	30	Apr. 8, 1930	do	Destroyed, Apr. 18.
6	2V74	Oct. 24, 1929	30	Apr. 8, 1930	do	Destroyed, Apr. 16.
7	C703	Oct. 24, 1929	30	Apr. 8, 1930	do	Destroyed, Apr. 17.
Control	0B15			Apr. 8, 1930	do	Destroyed, Apr. 16.

These animals had been injected with anatoxin Lot "D" approximately six months previous to being tested for immunity (Table 9).

The same infective material was used in this test as was employed in the first series. The spores were not heated.

No explanation can be made for the apparent total lack of immunity in these animals which had been injected with anatoxin about five and one-half months previously.

CONCLUSIONS

1. Immunization of guinea pigs against tetanus infection was easily accomplished by the injection of anatoxin prepared according to the technic of Ramon.
2. Precipitating, drying, and pulverizing of anatoxin resulted in a complete loss of the immunizing properties.
3. Tetanus anatoxin is harmless in large doses when given to large or small animals.
4. The results of experimental investigation of the protection afforded horses and mules by the injection of anatoxin were conflicting. In the first series, two of three animals were protected for a period of at least one month, one of three animals was protected for a period of about six months, while all of four animals tested one year after the administration of anatoxin were protected and one developed slight symptoms of infection but recovered. In the second series, seven horses died following the injection of tetanus spores, five and one-half months after the administration of anatoxin.

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EXPERIMENTAL STUDIES OF THE TREATMENT OF SURRA [1]

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NINE TEXT FIGURES

Surra, a term of Hindustani origin, meaning "rotten" or "spoiled," has been employed for many years to indicate a disease of certain wild and domesticated animals caused by *Trypanosoma evansi.*

The disease is characterized principally by fever; accelerated respiration; subcutaneous œdematous plaques and œdematous swellings of the genitals, limbs, and abdomen; marked emaciation despite an apparently good appetite; incoördination of gait; posterior paralysis and death.

The incubation period is from about four to fourteen days in natural infection and about five to eight days in cases that are deliberately induced.

Diagnosis is made by observation of clinical symptoms, by microscopic examination of peripheral blood for trypanosomes, and by the complement-fixation test.

Concerning the question of the actual cause of death of rats suffering with trypanosomiasis, Kligler, Geiger, and Comaroff (1) state that Schilling and Rondoni, Martin and Darre, Reichenow and Regendanz, and Tropp assume that the injury and ultimate death are due to a toxic substance liberated by the disintegration of the parasites. Schern and Fenyvessy hold that death is due to depletion of the blood sugar and glycogen reserve. Kligler

[1] From the United States Army Medical Department Research Board, Bureau of Science, Manila, Philippine Islands.

et al. state that while there is a general agreement that the blood-sugar concentration is decreased, no attention has been given to the possible harmful effects of intermediate products of sugar metabolism, and they are of the opinion that the lowered sugar concentration in the blood is due to its active utilization by the trypanosomes, and that this active glucose metabolism leads to a state of constant high lactic acid concentration in the blood. In experiments with normal and infected rats, they show that the increase in lactic acid is parallel to the rise in the number of trypanosomes, in some instances relatively enormous. This observation was carried out by tests with two sets of rats infected with *T. evansi*. One set was untreated, while twice daily the other received 0.5 cubic centimeter of a 10 per cent solution of bicarbonate of soda, intraperitoneally. The rats treated with soda bicarbonate lived half as long again as the untreated.

Edwards,(2) reporting his results in the treatment of surra with tartar emetic, states that the drug, when administered intravenously to a horse showing trypanosomes in its peripheral circulation, brings about disastrous results, the animal sometimes dying even before the termination of the injection. As examination of the peripheral circulation showed that the trypanosomes had disappeared, it was presumed that death had been caused by the occlusion of the capillaries with dead trypanosomes or, possibly, by the liberation of toxic products during their disintegration. He, therefore, recommended that the infected blood be initially freed of organisms either by administration of small amounts of tartar emetic or some other less drastic trypanocide, before more active treatment is begun.

The writers also have met with embarrassing results by the use of tartar emetic, but believe that such results were due to toxicity of the drug rather than to the occlusion of capillaries or to the liberation of toxic products from disintegrating trypanosomes. The deaths that occurred in certain of our cases followed in from one to three days after injections of the drug and at a time when trypanosomes had not been found in the peripheral circulation for a period of one month. The suggestion of Edwards, that certain animals appear to manifest an idiosyncrasy towards tartar emetic, is agreed with; but the writers, in harmony with Kligler and others, do not feel that death results from the liberation of toxic products, as the inoculation of the rats with large numbers of dead trypanosomes

as well as the rapid cure (five hours) of moribund rats teeming with trypanosomes, have failed to cause any symptoms of intoxication.

While it has been definitely proved that *T. evansi* may be carried in a mechanical manner by certain biting flies, there is no evidence to show that any cyclic development of the organism takes place within the bodies of such insects. According to Mitzmain,(3) the principal vector in the Philippines is *Tabanus striatus.* This observation was confirmed by Kelser,(4) who also incriminated the mosquito *Aëdes ægypti* as a mechanical carrier. Neither of these authors was successful in his endeavors to transmit the disease through the agency of *Stomoxys calcitrans.*

Surra occurs in India, Africa, Burma, Indo-China, Persia, Mauri, Java, Sumatra, and the Philippine Islands, and, owing to its fatal termination in horses, cattle, camels, goats, sheep, and dogs, it is of great importance to any country where such animals are factors in economic development. In the Philippines mules, horses, and native ponies are most susceptible, while the native carabao is relatively immune, and acts as a reservoir of the trypanosomes. However, the carabao may also succumb to the disease, if, for any reason, its vitality is lowered. Kelser,(4) in a survey in the Philippine Islands, embracing several hundred animals, found that over 50 per cent of the carabaos and more than 33 per cent of the native cattle showed evidence of harboring *T. evansi.*

Surra is rather widespread in the Philippines and in some localities is so prevalent as to prevent the maintenance of horses, so necessary to herding and other activities in connection with the cattle industry. During a period of twelve years 2,670 cases of surra were recorded in horses alone, to say nothing of the many cases not reported.

The United States Army in the Philippine Islands lost six horses and forty mules during an outbreak at Fort William McKinley in 1926; two mules at the same post in 1929; and twenty-six horses and two hundred eighty-nine mules at Fort Stotsenburg during an outbreak in 1929. At these posts the number of cases was kept at a minimum by isolation and strict quarantine of all animal suspects and by destruction and disposal of those known to be diseased.

Because of the ever present reservoirs of trypanosomes afforded by native cattle and the ubiquitous carabao, and the prev-

alence of insect vectors, surra in the Philippine Islands is a disease of serious importance to both civil and military activities.

For a considerable period of time before 1880, when Griffith Evans first discovered and proved the etiological significance of the flagellated protozoan in the blood of horses, mules, and camels suffering with surra, investigators had employed many drugs, alone and in combination, in an effort to discover an effective therapeutic agent for this disease.

Hornby,(5) commenting on the treatment of trypanosomiasis of cattle (Nagana), summarized his results as follows:

> Ten bulls were put into thick fly near Shinyanga Tanganyika Territory, and six were dead within three months and none survived eight months. Of ten bulls put into the same fly belt, but injected every fortnight of the first five months with 1 gram of tartar emetic, only two died within seven months; the remaining eight were in marketable condition, although infected with trypanosomes at the end of that period. Of ten bulls put in the same fly belt, but injected every fortnight of the first five months with a mixture of 2.5 gms. of Bayer 205 and 1 gram of tartar emetic, three were dead within seven months. Of the survivors one was very ill at the end of that time, but, the remaining six were in marketable condition though infected.

He concluded that "no advantage is obtained when Bayer 205 is added to the tartar emetic." Edwards,(2) in an article dealing with various investigations including his own, states that "according to Dale (1923), Cushny made the first suggestion of a trial of compounds of antimony and bismuth on account of their relationship with arsenic. Low (1916) in a review of the history of the use of tartar emetic in tropical medicine, stated that Nicholle and Mesnil (1906) first proposed the use of antimony salts in the treatment of trypanosomiasis." In his summary and conclusions, Edwards speaks highly of Bayer 205 as a trypanocide and calls attention to its ability to remain in the circulation for about two months, thus protecting the patient from relapses. He states, however, that the lack of diffusibility of the drug is a detracting feature as it does not reach the trypanosomes in the subarachnoid space. He overcame this shortcoming by administering dilute solutions of Bayer 205 intrathecally simultaneously with intravenous injections. He is of the opinion that Bayer 205 can be used alone with success, and that its action is superior to tartar

emetic. Edwards stated that results with tryparsamide were disappointing.

Tubangui(6) reported having successfully treated two native ponies with alternating doses of mercuric iodide and tartar emetic given intravenously, and with anthelmintics, the use of which was suggested by the theory that blood-sucking internal parasites may act as reservoirs and reinfect after termination of treatment.

Ch. Kahan Singh(7) reported encouraging results obtained with Bayer 205 and tartar emetic used in the treatment of surra in native ponies. He stated that of four animals treated at Sohawa, one died during medication while three were discharged as cured and were in good health at the time of his report. Thirteen out of fourteen cases admitted at Bhera received treatment and were alive and improving generally. Of forty-four cases admitted to the Veterinary Hospital at Quilla Sheikhupura, thirty-six received the full course of treatment, six died during medication, and two were taken away before completion of the therapy. Eight of the thirty-six discharged as cured relapsed, probably due to reinfection. The other twenty-eight were apparently normal. He also called attention to other observations which indicate that his method of treatment produced favorable results. All injections were made intravenously and were intended for the average-sized pony. The amount of drugs used, as well as the time intervals between injections, were as follows:

First day, 100 cubic centimeters of 2 per cent solution Bayer 205.
Sixth day, 100 cubic centimeters of 1 per cent solution tartar emetic.
Eleventh day, 150 cubic centimeters of 1 per cent solution tartar emetic.
Sixteenth day, 100 cubic centimeters of 2 per cent solution Bayer 205.
Twenty-first day, 150 cubic centimeters of 1 per cent solution tartar emetic.
Thirty-first day, 100 cubic centimeters of 2 per cent solution Bayer 205.

Stratman-Thomas and Loevenhart,(8) after commenting on the therapeutic value of a number of compounds that have been used as trypanocides, present data on the general biological actions of two of the six most promising drugs prepared by them. These two preparations were called etharsanol and proarsanol.

Etharsanol (drug "73"), or "para-oxyethylphenylarsenic acid," was first prepared by C. S. Hamilton in the laboratories of

Doctor Loevenhart. The arsenic content is 20.32 per cent; and it is stated that a 10 per cent solution of etharsanol can be heated in the sterilizer at 15 pounds pressure for thirty minutes without materially increasing its toxicity.

Stratman-Thomas and Loevenhart(8) state that ten to fourteen days after inoculation with trypanosomes the brain of untreated rabbits contained living organisms, as an emulsion of this brain tissue injected into rats produced trypanosomiasis. At the same time the blood was free of trypanosomes, as none could be found on careful microscopic examination, and the inoculation of the blood into rats failed to produce infection. However, it was also stated that following the injection of etharsanol the brain substance contained large amounts of arsenic and from this it was concluded that etharsanol is able to penetrate the tissues of the central nervous system and kill trypanosomes located there. These workers, who repeated the work of Voegtlin(9) and obtained similar results as with tryparsamide, state that etharsanol is equally as effective in clearing the cerebrospinal fluid of trypanosomes, when the technic described by Voegtlin, Smith, Dyer, and Thompson was used. Stratman-Thomas and Loevenhart (p. 476) concluded:

> The real test of a drug, however, is in animals where the infection is in the tissues, and not confined to the blood stream, and where therapeusis is started late in the disease. In rabbits, there seems to be little preference between the efficacy of etharsanol and tryparsamide. Etharsanol is capable of curing trypanosomal infections in rats and rabbits late in the disease and in some cases when the animal is near the point of death.

Other factors of importance are the relatively low cost of production of etharsanol and the excellent keeping qualities of this drug.

Two lots of etharsanol (Nos. 15 and 16) were furnished Vedder and Kelser(10) while they were members of the Medical Department Research Board, by Stratman-Thomas and Loevenhart, and are now being employed by the writers. This material is about four years old, and has been stored in loosely stoppered amber bottles and kept on a shelf in the laboratories of the Bureau of Science, Manila, Philippine Islands.

From the unpublished results of an experimental investigation of the treatment of surra by Vedder and Kelser,(10) it may be concluded that etharsanol (drug "73") is effective in the treat-

ment of rats infected with *T. evansi*, but that horses and mules failed to tolerate a curative dose and died of arsenical poisoning.

EXPERIMENTAL

The authors repeated the observations of Vedder and Kelser concerning the cure of infected rats by etharsanol and stimulated by its obvious trypanocidal action, continued the study of this drug in an endeavor to develop a method of administration by which its toxic action could be minimized and the disease cured in horses. In the present investigation etharsanol was used for the treatment of *T. evansi* infections in rats, horses, and mules.

DISTRIBUTION OF TRYPANOSOMA EVANSI IN THE TISSUES OF INFECTED RATS

In order to determine the location of trypanosomes in the various tissues of infected rats, which have received subtherapeutic doses of etharsanol resulting in apparent sterilization of the peripheral blood, the following experiments were carried out.

Experiment 1.—May 22, 1928. Four normal white rats were inoculated with *T. evansi*, and when trypanosomes appeared in the peripheral blood three days later three of the animals were injected intraperitoneally with subtherapeutic doses (20 milligrams) of etharsanol. On the following day (May 26) blood specimens from the three treated rats were free of organisms while the control remained positive. Rat 1 was killed May 26 and portions of heart, lymph glands, spleen, kidney, adrenal, liver, and bone were each macerated separately with physiologic salt solution and injected with separate syringes intraperitoneally into normal rats, as shown in Table 1–A. The results in Table 1 show that while the peripheral blood of rat 1 was free of trypanosomes, these organisms were present in all organs with the exception of the adrenals. The susceptibility of the rat injected with adrenal was proved by infection fifteen days later with *T. evansi*. The rat that received the extract of heart muscle died the following day from a puncture of the intestines.

Rat 2 had trypanosomes in the peripheral blood on the fifth day after the injection of etharsanol and died of the infection three days later, indicating that the 20-milligram dose was insufficient to effect a cure. Rat 3 showed similar results after seven days and died the following day. The control rat (No. 4), which was not treated, had trypanosomes in the blood from the third day after inoculation until death on the tenth day.

TABLE 1.—*Experiment 1: Result of inoculation of trypanosomes into four rats.*

[+, all infected May 22, 1928. Trypanosomes in blood.]

Rat No.	Trypanosomes in blood.	Injected with etharsanol May 25, 1928.	Blood examination.								
			May.						June.		
			26	27	28	29	30	31	1	2	3
		mg.									
1	May 25	20	— [a]								
2	May 25	20	—	—	—	—	+	+	+	Died.	
3	May 25	20	—	—	—	—	—	—	+	Do.	
4	May 25	[b]	+	+	+	+	+	+	+	Do.	

[a] Killed June 26. See Table 1–A. [b] Control.

TABLE 1–A.—*Normal rats inoculated May 26 with tissue extracts from rat 1 of Table 1.*

[D, died.]

Rat No.	Tissue.	Results.																					
		May.		June.																			
		30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Heart	D [a]																					
2	Lymph gland	—	—	—	—	+	+	+	D														
3	Spleen	—	—	—	—	+	+	+	D														
4	Kidney	—	—	—	—	+	+	+	+	D													
5	Adrenal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— [b]	—	—	+	+	+	+	D
6	Bone	—	—	—	+	+	D																
7	Liver	—	—	—	—	—	—	—	+	D													
8	Tail blood	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[c]

[a] Punctured intestines. [b] Inoculated with *T. evansi*. [c] Discarded.

Experiment 2.—August 31, 1928. Three rats were infected with *T. evansi* and all had trypanosomes in their blood September 4, at which time rats 1 and 2 were each given 20 milligrams of etharsanol intraperitoneally.

The control rat, No. 3, which had not been treated, had trypanosomes in the blood from the fourth day after infection until death on the eighth day.

The blood of rat 2 showed no trypanosomes on the first, second, third, fourth, or fifth day after treatment, but was positive from the sixth to the tenth day when it died of the infection.

Rat 1 had no demonstrable trypanosomes in the blood during the two days following treatment. This animal was killed on

TABLE 2.—*Experiment 2: Result of inoculation of trypanosomes into three rats.*

[D, died. All rats infected August 31, 1928.]

Rat No.	Trypanosomes in blood.	Injected with etharsanol Sept. 4, 1928.	Results.									
			September.									
			4	5	6	7	8	9	10	11	12	13
		mg.										
1	Sept. 4	20	+	—	— [a]	----	----	----	----	----	----	----
2	Sept. 4	20	+	—	—	—	—	—	+	+	D	----
3	Sept. 4	[b]	+	+	+	+	D	----	----	----	----	----

[a] Killed September 6 for rats in Table 2–A. [b] Control.

TABLE 2–A.—*Normal rats inoculated September 6 with tissue extracts from rat 1 of Table 2.*

[D, died.]

Rat No.	Tissue.	Results.												
		September.												
		9	10	11	12	13	14	15	16	17	18	19	20	21
1	Heart	—	—	—	—	—	—	—	+	+	D	----	----	----
2	Lymph glands	—	—	—	—	—	—	—	—	—	—	—	—	—
3	Spleen	—	—	—	—	—	—	—	—	—	—	—	—	—
4	Kidney	—	—	—	—	—	—	+	+	+	+	+	+	+
5	Adrenal	—	—	—	—	+	+	+	+	D	----	----	----	----
6	Bone	—	—	—	—	—	—	—	—	—	—	—	—	—
7	Liver	—	—	—	—	—	+	+	D	----	----	----	----	----
8	Brain	—	—	—	—	—	—	—	—	—	—	+	+	+
9	Tail blood	—	—	—	—	—	—	—	—	—	—	—	—	—

Rat No.	Tissue.	Results.												
		September.									October.			
		22	23	24	25	26	27	28	29	30	1	2	3	5
1	Heart	----	----	----	----	----	----	----	----	----	----	----	----	----
2	Lymph glands	—	—	—	—	—	—	— [a]	—	—	+	+	+	D
3	Spleen	—	—	+	+	+	D	----	----	----	----	----	----	----
4	Kidney	+	D	----	----	----	----	----	----	----	----	----	----	----
5	Adrenal	----	----	----	----	----	----	----	----	----	----	----	----	----
6	Bone	+	+	+	D	----	----	----	----	----	----	----	----	----
7	Liver	----	----	----	----	----	----	----	----	----	----	----	----	----
8	Brain	D	----	----	----	----	----	----	----	----	----	----	----	----
9	Tail blood	—	—	—	—	—	—	— [a]	—	—	+	+	+	D

[a] Inoculated with *T. evansi.*

the latter day and the various organs were removed, suspended in salt solution, and inoculated into normal rats. As shown in Table 2–A trypanosomes were still present in the heart, spleen, kidney, adrenal, bone, liver, and brain.

From these results it may be seen that while a subtherapeutic dose of etharsanol temporarily freed the peripheral circulation of trypanosomes, the organisms were still present in various internal organs.

Experiment 3. To test the effectiveness of etharsanol and tartar emetic used in subtherapeutic doses for treatment of rats infected with T. evansi.

The work of Vedder and Kelser demonstrated that the peripheral blood of horses given a subtherapeutic dose of etharsanol remained free of detectable trypanosomes for a period of only about eleven days. It seems probable that during this period the organisms must be in the internal organs. From the reports of Stratman-Thomas and Loevenhart, it appears that etharsanol has the property of invading the meninges and spinal fluid, while the reports of many investigators indicate that tartar emetic exerts a drastic effect upon trypanosomes in the peripheral circulation. Thus it was considered probable that if blood could be sterilized with tartar emetic and if the trypanosomes located in the spinal canal, deeper tissues, and organs could be reached by etharsanol, and the administration of the drugs so regulated as to prevent a cumulative action, the disease might be cured. Therefore, in this experiment white rats infected with *T. evansi* were treated with relatively small doses of tartar emetic alternating with etharsanol at intervals of about five days. The largest dose of etharsanol given was 20 milligrams, which is approximately one-third the amount required as a single dose to cure infected rats.

June 15, 1929. Ten normal white rats were inoculated with *T. evansi.* Four days later trypanosomes were present in the blood of all these animals. On this day eight of the rats were treated with different amounts of etharsanol, one was treated with tartar emetic, and one untreated animal was kept as a control. The control animal died on the seventh day after inoculation. Rat 9, which had been given 1 cubic centimeter of a 1 per cent solution of tartar emetic, died in twenty-four hours, apparently due to the toxicity of the drug, which prompted the use of a weaker solution for subsequent injections. Rat 8, treated with one dose of etharsanol (20 milligrams), showed

no trypanosomes in the blood for four days and then became positive and remained so until the tenth day when death occurred. Rat 1, which was given 5 milligrams of etharsanol, died the following day from an undetermined cause. The six remaining rats, Nos. 2, 3, 4, 5, 6, and 7, received alternating doses of etharsanol and tartar emetic, as shown in Table 3.

No trypanosomes were found in the blood of rat 2 during the period from June 30 to August 22, or fifty-three days; rat 5 showed no trypanosomes during the period from June 30 to August 1, or forty-three days; and the same was true of rats 3, 4, and 6 from July 6 to August 22, or forty-seven days. August 22 all live rats were inoculated with *T. evansi* to determine their susceptibility and all died from surra.

From the above results it would appear that while 20 milligrams of etharsanol alone were not sufficient, 15 milligrams of etharsanol and 1 cubic centimeter of a 1 to 300 solution of tartar emetic, in alternate doses were enough to cure *T. evansi* infection in the average white rat weighing from 180 to 200 grams.

The observation that small doses of etharsanol, in combination with tartar emetic, were sufficient to produce a permanent cure in rats indicated that perhaps a similar procedure might prove effective in the treatment of larger animals. Consequently, eight horses and one mule, all condemned animals, were obtained from the Quartermaster, Philippine Department, and used for experimentation. They were kept at the laboratory of the veterinary research division, Philippine Bureau of Animal Industry.

It might be well to state that in treating animals with tartar emetic, care should be exercised that none of the drug escapes into the subcutaneous tissues. Should this occur, extensive, painful swellings result, making it difficult to locate the jugular at the time of subsequent treatments, to say nothing of the apparent discomfort to the animal.

It has been our practice to dissolve the drug in distilled water immediately prior to intravenous injection and administer the solution slowly, and intermittently. Upon completion of the injection, the jugular vein was dammed and a quantity of blood was allowed to flow out through the needle, thus washing it clear of the drug before withdrawal.

Temperatures of nine normal horses, taken at 6 a. m. for a period of one week during February showed an average of 100.2° F. The highest was 100.4° F. and the lowest 98.1° F.

The majority showed temperatures of 100° F. or more. Temperatures of ten normal animals, taken in the evening for a period of one week during the month of February, showed an average temperature of 99.7° F. The highest was 101° F. and the lowest 99° F. In twenty-seven instances the temperature was 100° F. or more, while the remaining forty-three temperatures were above 99° F.

A modification of Broden's(11) method was employed to detect small numbers of trypanosomes microscopically. From 5 to 10 cubic centimeters of blood was allowed to flow from the jugular vein into several cubic centimeters of physiological salt solution containing 1 per cent sodium citrate. This was centrifuged at high speed, thus forcing the erythrocytes and trypanosomes to the bottom. The trypanosomes being of lower specific gravity than the cells, were found in the thin surface of the precipitate. A representative portion of the upper stratum was removed with a pipette and examined in the moist state with the high dry lens. Trypanosomes are easily demonstrated by this method, and the chances for their detection are many times greater than by the single-drop method. Such examinations were made each day during the experiment.

The complement-fixation test for surra was employed in conjunction with the microscopic examination of peripheral blood. The antisheep hæmolytic system, using one and one-half units of amboceptor and two units of complement was used. The antigen, a fresh suspension of *T. evansi*, was prepared after the method of Reynolds and Schoening.(12) In recording the results of the complement-fixation tests in the tables, the following symbols were employed: 4 +, complete fixation of complement; 3 +, 75 per cent fixation; 2 +, 50 per cent fixation, 1 +, 25 per cent fixation; + –, less than 25 per cent fixation; –, complete hæmolysis; and a dotted line indicates no test that particular day.

When the experimental animals were killed specimens from either brain, spleen, or spinal fluid were mixed with salt solution, and 1 cubic centimeter amounts were injected into white rats. After the rats had remained free of trypanosomes for twenty days they were then inoculated with *T. evansi* in order to demonstrate their susceptibility.

Charts and protocols explaining the daily observations on each experimental animal follow in chronological order.

TABLE 3.—*Rats inoculated with Trypanosoma evansi June 15, 1929, and treated with etharsanol (drug "73") and tartar emetic.*

[0, no treatment; +, trypanosomes in peripheral circulation; —, no trypanosomes in peripheral circulation; D, dead; TE, tartar emetic; drug "73," etharsanol.]

No.	June.															July.						
	19		20	21	22	23	24		25	26	27	28	29		30	1	2	3	4	5		6
	Drug "73."						TE 1-500.						Drug "73."							TE 1-500.		
		g.						*cc.*						*g.*							*cc.*	
1	+	0.005	D																			
2	+	0.006	+	—	—	—	+	1.0	—	—	—	—	+	0.01	—	—	—	—	—	—	1.0	—
3	+	0.007	+	+	+	+	+	1.0	—	—	—	—	+	0.01	—	—	—	—	+	+	1.0	—
4	+	0.008	+	—	—	—	+	1.0	—	—	—	—	+	0.01	—	—	—	—	—	+	1.0	—
5	+	0.009	+	—	—	—	+	0.5	—	—	—	—	+	0.01	—	—	—	—	—	—	1.0	—
6	+	0.010	—	—	—	—	+	0.5	—	—	—	—	—	0.01	—	—	—	—	—	+	1.0	—
7	+	0.015	+	—	—	—	+	0.5	—	—	—	—	—	0.01	—	—	—	—	+	+	1.0	D
8	+	0.020	+	—	—	—	—	0	+	+	+	+	D									
9	+	(a)	D																			
10	+	0	+	+	D																	

TABLE 3.—*Rats inoculated with Trypanosoma evansi June 15, 1929, and treated with etharsanol (drug "73") and tartar emetic*—Continued.

[0, no treatment; +, trypanosomes in peripheral circulation; —, no trypanosomes in peripheral circulation; D, dead; TE, tartar emetic; drug "73," etharsanol.]

No.	July.									July 13 to Aug. 1.	August.												
	7	8	9		10	11	12	13			1	2 to 22	22	23	24	25	26	27	28	29	30	31
			Drug "73."					TE 1-300.														
				g.					*cc.*													
1																						
2	—	—	—	0.015	—	—	—	—	1.0	—	—	—	(b)	—	—	—	—	+	+	+	D	
3	—	—	—	0.015	—	—	—	—	1.0	—	—	—	(b)	—	—	—	—	+	+	+	+	D
4	—	—	—	0.015	—	—	—	—	1.0	—	—	—	(b)	—	—	—	—	+	+	+	+	D
5	—	—	—	0.015	—	—	—	—	1.0	—	D											
6	—	—	—	0.015	—	—	—	—	1.0	—	—	—	(b)	—	—	—	—	+	+	+	+	D
7																						
8																						
9																						
10																						

[a] One cubic centimeter of 1 per cent tartar emetic.

[b] Infected with *T. evansi*.

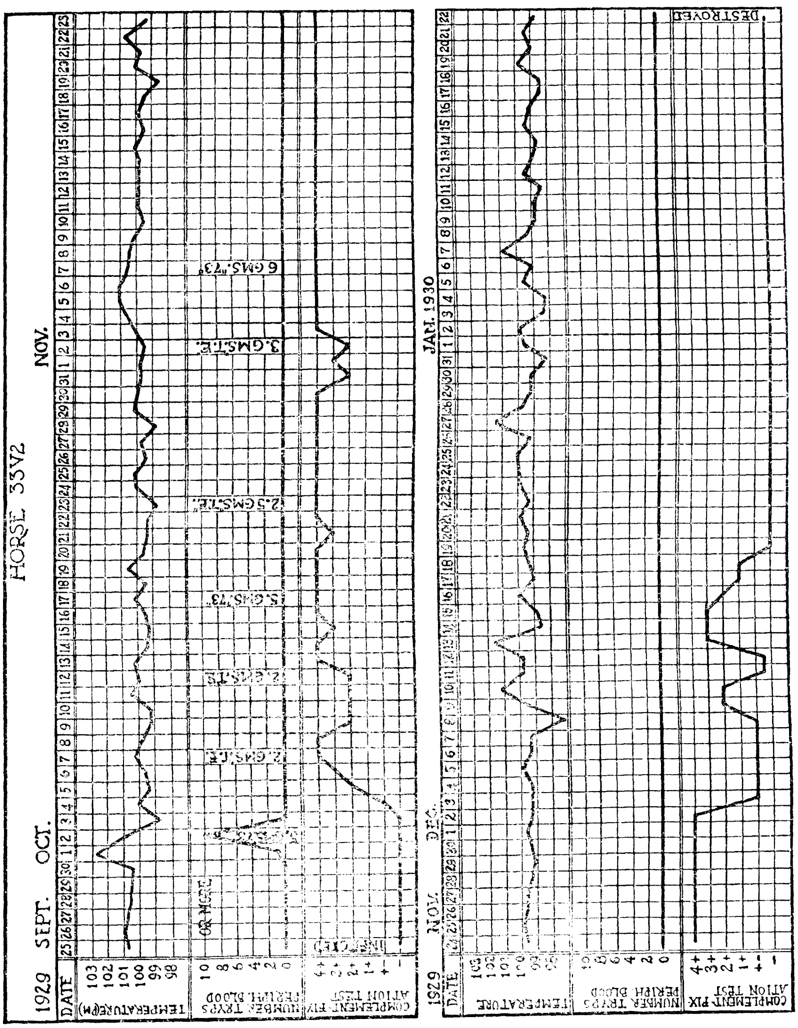

FIG. 1. Chart of horse 33V2.

EXPERIMENT 1

Horse 33V2. Inoculated with *T. evansi* September 25, 1929. Trypanosomes appeared in the peripheral circulation October 1, or six days subsequently. October 2 treatment was commenced with a 5-gram dose of drug "73." Treatment continued until November 7, when the last dose was given. Trypanosomes were not in evidence in the circulation the day following the initial treatment October 2, nor did they again appear during the experiment. Complement-fixing bodies appeared in the serum October 4 and continued in varying amounts until December 18, when the serum became negative and remained so to the termination of the experiment December 22, a period of thirty-five days. The daily temperature fluctuated considerably, but in the Tropics there is a wide variation in normal animals, and unless pyrexia is relatively high and associated with other clinical signs, such temperatures are of little significance.

This animal was apparently normal after the first treatment. No trypanosomes were found in the peripheral blood from the time of first treatment, a period of one hundred twelve days.

At the termination of the experiment January 22, 1930, blood, spinal fluid, brain, and spleen tissue were injected into white rats. They remained normal for twenty days, when their susceptibility was proved by inoculation with *T. evansi.*

Comment.—In view of the fact that the temperature remained normal after the first treatment, or one hundred twelve days; that trypanosomes were not found during a period of one hundred twelve days; that the complement-fixation test remained negative for thirty-five days; that the general health of the animal was excellent; that the blood, spinal fluid, brain, and spleen pulp were free from trypanosomes, it is believed that this case was cured by the treatment used.

EXPERIMENT 2

Horse 35V7. Weight 850 pounds. Inoculated with *T. evansi* November 18, 1929, and the peripheral blood showed trypanosomes November 25, or seven days subsequently. This animal was permitted to go untreated until December 4, or nine days after trypanosomes made their appearance. On the morning of December 4, it was given 8 grams of drug "73" and the blood was free of trypanosomes by the afternoon of the same day, and remained negative thereafter. December 13, nine days later, this horse was given 3 grams of tartar emetic and died the

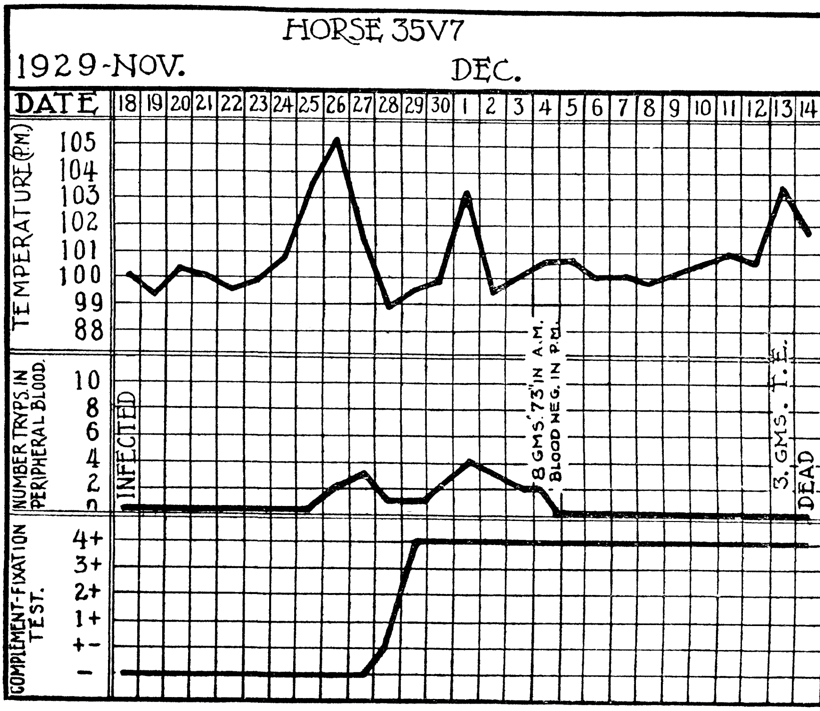

FIG. 2. Chart of horse 35V7.

following morning. Complement-fixing bodies made their appearance in the blood serum November 27, or nine days after infection and one day after the appearance of trypanosomes in the peripheral blood. Death was undoubtedly due to an overdose of the tartar emetic as will be seen in later protocols.

Rats inoculated with spleen pulp and spinal fluid from this animal remained normal for twenty days when their susceptibility was proven by an inoculation with *T. evansi.*

Comment.—No trypanosomes were found in this animal, which apparently died of poisoning by tartar emetic.

EXPERIMENT 3

Mule 572–W. Weight 850 pounds. This animal was old, anæmic, and with teeth no longer useful. It was infected with *T. evansi* December 26, 1929. Trypanosomes appeared in the blood January 2, or seven days after infection, and complement-fixing bodies appeared January 3, or eight days after infection.

Treatment commenced January 7, or five days after trypanosomes appeared in the blood. At this time it was intended to

give 7 grams of drug "73," but because of the weakness of this animal, the dose was decreased. For several days prior to January 6 the animal had not been eating, and just before treatment commenced there were œdematous swellings, especially about the knees. The œdema cleared up following the initial treatment, and the animal improved a little. February 3 the animal was moribund, probably due to the combination of old age, malnutrition, and the toxic effect of the last injection of 2.5 grams of tartar emetic.

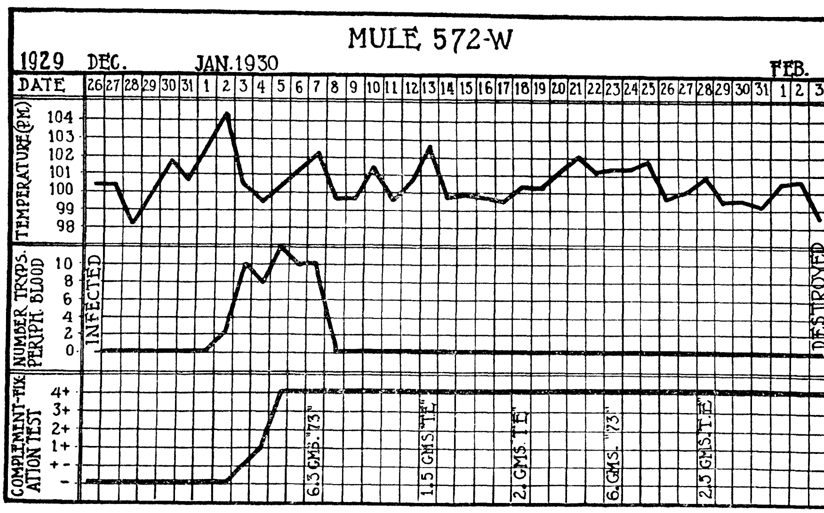

FIG. 3. Chart of mule 572–W.

Trypanosomes were not found in the peripheral blood following the first treatment, a period of twenty-seven days.

White rats injected with spinal fluid, spleen pulp, and brain tissue remained well for twenty days, when susceptibility was proven by inoculation with *T. evansi*.

Comment.—No trypanosomes were found in the animal from the beginning of treatment until death, which was probably due to poisoning by tartar emetic.

EXPERIMENT 4

Horse B–709. Weight 900 pounds. Infected with *T. evansi* February 11, 1930. Trypanosomes first appeared in the peripheral blood February 17, or six days subsequently. The initial dose of drug "73" was administered February 18, and the peripheral blood was negative for trypanosomes the following

day and remained so for the duration of the experiment. Complement-fixing bodies appeared February 19, or eight days following infection and two days following the appearance of trypanosomes in the circulation, and with the exception of a short period between March 1 and 6, inclusive, were present in varying amounts. March 24, the dose of tartar emetic was increased to 3 grams. The animal remained normal in appearance until March 29, when it showed general choreic symptoms with profuse sweating, and died suddenly.

Trypanosomes were absent from the circulation the date of the first treatment until death, twenty-nine days later.

White rats injected with material from the brain, spinal fluid, and spleen pulp remained normal for twenty days, when their susceptibility was tested by inoculating with *T. evansi.*

Comment.—No trypanosomes were found in this animal from the beginning of treatment until death, which was probably due to poisoning by tartar emetic.

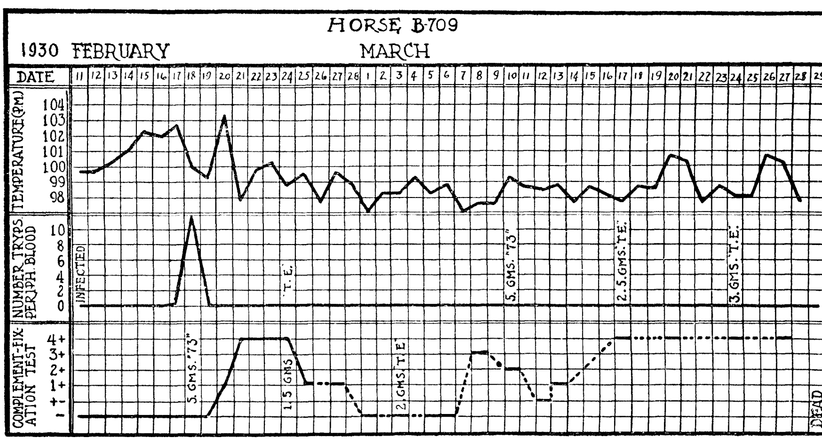

FIG. 4. Chart of horse B-709.

EXPERIMENT 5

Horse 32V6. Weight 900 pounds. Infected with *T. evansi* February 11, 1930. Trypanosomes appeared in the peripheral blood February 16, or six days after infection. Treatment was begun February 18, the second day after peripheral invasion. No trypanosomes were found the following day, nor at any time thereafter. March 24, 3 grams of tartar emetic were administered and the following day the animal showed marked cho-

reic symptoms of head and neck, with profuse sweating, and died within a few hours.

Trypanosomes were not found from the day following first treatment, a period of thirty-five days.

White rats injected with spleen pulp and spinal fluid collected at the time of death, remained normal for twenty days, when their susceptibility was tested by injection with *T. evansi*.

Comment.—No trypanosomes were found in this animal from the beginning of treatment until death, which was probably due to poisoning by tartar emetic.

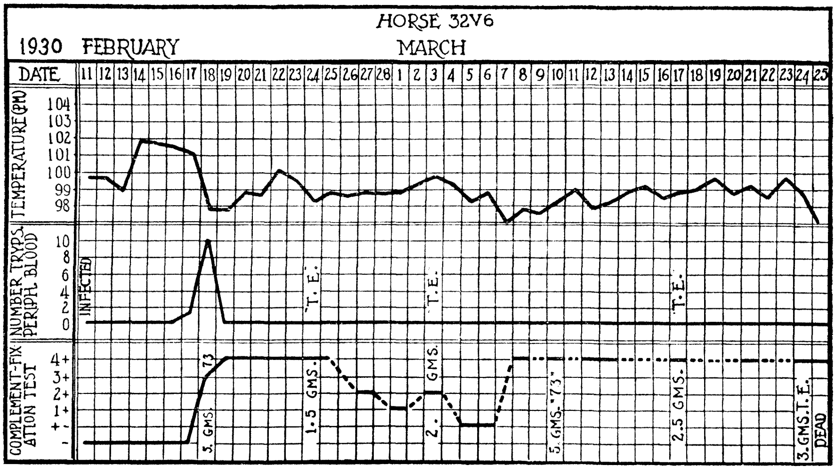

FIG. 5 Chart of horse 32V6.

EXPERIMENT 6

Horse C–932. Infected with *T. evansi* February 11, 1930. Trypanosomes appeared in the peripheral blood February 17, or the sixth day after infection. Treatment was commenced the day following, February 18. The trypanosomes disappeared and the circulation remained free thereafter, a period of thirty-six days. Complement-fixing bodies appeared February 18, seven days after infection and one day following the appearance of trypanosomes in the circulation. March 24, 3 grams of tartar emetic were administered, which proved too great a dose. Two days later, March 26, the animal was sweating profusely, and after showing some muscular twitching, died.

White rats inoculated with spleen pulp and spinal fluid from this animal, remained normal for twenty days when their susceptibility was tested by infection with *T. evansi*.

Comment.—No trypanosomes were found in this animal from the beginning of treatment until death, which was probably due to poisoning by tartar emetic.

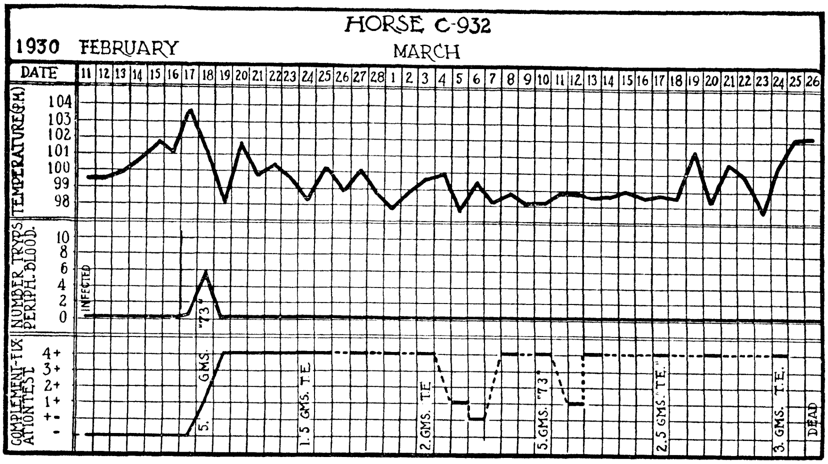

FIG. 6. Chart of horse C–932.

EXPERIMENT 7

Horse 06V8. Age 20 years. Weight 1,250 pounds. This animal was infected with *T. evansi* February 11, 1930. Trypanosomes appeared in the peripheral circulation February 17, or six days following infection. Treatment commenced on the following day, and the peripheral blood was negative for trypanosomes February 19 and continued thus until April 21, when this animal suffered from a relapse. Treatment was again given February 22. The blood was negative the following day and remained so up to the date of destruction of the animal, May 13. April 16, or five days prior to the reappearance of trypanosomes, the complement-fixation test, which had been plus-minus for six days, suddenly became four plus and continued at that level until termination of the experiment. White rats injected with spleen pulp and spinal fluid from this horse at the time of destruction, May 13, remained normal for twenty days when their susceptibility was proved by inoculation with *T. evansi.*

Comment.—It is apparent that in this particular case the initial treatment was not sufficient to destroy all the trypanosomes, as a relapse occurred sixty days after the last injection of the drugs. Had the course of chemotherapy been continued for a

few weeks longer, a cure might have been effected. The value and the accuracy of the complement-fixation test are demonstrated in this case.

EXPERIMENT 8

Horse 05V9. Age 20 years. Weight 1,500 pounds. Infected with *T. evansi* February 11, 1930. Trypanosomes appeared in the peripheral blood February 17, the sixth day after infection. Treatment was commenced February 18, one day following the appearance of trypanosomes. The day following treatment the peripheral circulation was negative for trypanosomes and remained so during the remainder of the experiment, or a period of eighty-three days.

Complement-fixing bodies first appeared February 18, the seventh day following infection and the day following appearance of trypanosomes in the peripheral blood. After fluctuating for forty-two days, the test became negative and remained so during the rest of the experiment, a period of forty-two days.

May 13 the animal was destroyed, and spinal fluid and spleen pulp were injected into white rats. The rats remained normal for a period of twenty days when their susceptibility was tested by the inoculation of *T. evansi.*

Comment.—In view of the fact that the temperature remained normal after the first treatment (eighty-one days); that trypanosomes were not found during a period of eighty-four days; that the complement-fixation test remained negative for forty-one days; that the general health of the animal was excellent; and that the spinal fluid and spleen pulp were free of trypanosomes, it is believed that this case was cured by the treatment used.

EXPERIMENT 9

Horse C936. Age 10 years. Weight 1,025 pounds. Infected with *T. evansi* February 11, 1930. Trypanosomes made their appearance February 17, or six days after infection. February 18 treatment was commenced. No trypanosomes were found in the peripheral circulation the day following first treatment, nor were any found during the remainder of the experiment, a period of eighty-four days.

Complement-fixing bodies were demonstrated in the serum the seventh day following infection and one day after trypanosomes were found in the circulation. After some fluctuation the fixation test became negative April 8 and remained so for the duration of the experiment, a period of thirty-five days.

The animal was destroyed May 13, and white rats were injected with spleen pulp and a part of the spinal fluid. All rats remained normal for twenty days, when their susceptibility was tested by injection of *T. evansi.*

Comment.—As the temperature remained normal for approximately three months following initial treatment; as no trypanosomes were found in the peripheral circulation following the first treatment; as the complement-fixation test remained negative for a period of thirty-five days; as no trypanosomes could be demonstrated in emulsion of the spleen and spinal fluid by animal inoculation; and as the general health of this animal was excellent at all times, it is concluded that the treatment given this animal effected a cure.

SUMMARY AND CONCLUSIONS

1. It was shown that rats infected with *T. evansi* may be cured by alternating injections of tartar emetic and etharsanol in doses smaller than the amount required when the latter drug is used alone.

2. The use of larger amounts of these drugs in the treatment of infected horses and mules gave results which are considered to be of sufficient promise to warrant further study.

3. Five animals, each of which weighed less than 1,000 pounds, died during treatment, probably due to poisoning by tartar emetic. However, none of these animals had trypanosomes in the blood at any time after the first treatment; and the organisms were not demonstrable in their spinal fluid, or in certain of their organs, extracts of which were inoculated into susceptible white rats.

4. In one experiment the blood remained free from trypanosomes for sixty days, after which a relapse occurred. However, following additional treatment the blood again became negative and remained so for twenty days, after which the animal was killed. Suspensions of the spinal fluid and spleen injected into susceptible rats failed to produce infection.

5. In three experiments the animals were apparently cured of surra, as indicated (*a*) by the immediate disappearance and permanent absence of trypanosomes from the blood, (*b*) by the fact that symptoms disappeared and the temperature remained normal, (*c*) by the findings that the complement-fixation test became negative and remained so, and (*d*) by the fact that suspensions of the spinal fluid and spleen injected into susceptible rats failed to cause infection.

6. In view of the fact that a relapse occurred in one animal after a period of sixty days, it seems important that further experimental studies be made to so modify the course of treatment either by prolonging it or preferably by increasing the amounts of etharsanol, that the possibility of relapses may be prevented.

ACKNOWLEDGMENTS

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart of horse 33V2.
2. Chart of horse 35V7.
3. Chart of mule 572-W.
4. Chart of horse B-709.
5. Chart of horse 32V6.
6. Chart of horse C-932.
7. Chart of horse 6V8.
8. Chart of horse 05V9.
9. Chart of horse C936.

ANALYSIS AND FOOD VALUE OF SOME UNUSUAL PHILIPPINE FRUITS

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NINE PLATES

Several papers on the composition of the common Philippine fruits [1] have been published. The object of the present investigation was to determine the composition of several unusual Philippine fruits that are not commonly known, and are used by Filipinos as food only in certain localities.

EXPERIMENTAL PROCEDURE

Analyses of these Philippine fruits were made according to the methods of the American Association of Official Agricultural Chemists and also Leach's Food Analysis.

When the fruits were received they were allowed to ripen, if they were not yet ripe, and were then weighed as whole fruits. In preparing samples for analysis the peelings and seeds were removed from the larger fruits and discarded and the edible portion weighed and ground to a uniform mass. In preparing samples of the very small fruits the whole fruit, including the seeds and peelings, were ground to a uniform mixture. As customary in food analysis the common constituents were determined individually, but the percentage of carbohydrates other than sugars and crude fiber was obtained by

[1] Santos, F. O., and F. T. Adriano, Bull. Philip. Public Welfare Commission, Manila (1928). Wester, P. J., Bull. Philip. Bur. Agr. **39** (1925). Pratt, D. S., and J. I. del Rosario, Philip. Journ. Sci. § A **8** (1913) 59. Wells, A. H., F. Agcaoili, H. Taguibao, and A. Valenzuela, Philip. Journ. Sci. **36** (1928) 157. Valenzuela, A., and P. J. Wester, Philip. Journ. Sci. **41** (1930) 85. Salvador W., Philip. Journ. Sci. **20** (1922) 363.

subtracting the total percentage of the other constituents from 100. Analyses of these fruits are given in Tables 1 and 2.

DESCRIPTION OF FRUITS

ANONA sp. Atemoya. Plate 1, fig. 1.[2]

A small deciduous tree of rapid growth adapted to low and medium altitudes, succeeds well where the dry season is pronounced.

The leaves and flowers are similar to those of cherimoya. The fruits are somewhat like the cherimoya in appearance but smaller, and are sweet, juicy, subacid, and of a good to excellent quality, but in most seedlings a shy bearer. A hybrid between the cherimoya and sugar apple. Fruited for the first time at Lamao experiment station in 1913.

ARTOCARPUS ELASTICA Reinw. Gomihan. Plate 1, fig. 2.

A tree of medium to large size, sometimes more than 15 meters high, growing at low altitudes in regions with abundant rainfall of equal distribution, from southern Luzon to Mindanao. The leaves are large, entire or trilobed, dark green, and rather rough beneath. The fruit is roundish, about 10 centimeters across, orange-yellow, and covered with long coarse threadlike hairs. The flesh is whitish, sweet, juicy, aromatic, and of good taste but rather scant. The seeds are roasted and eaten like peanuts.

ARTOCARPUS ODORATISSIMA Blanco. Maráng. Plate 2, fig. 1.

A handsome tree of medium to large size, about 20 meters high, found in Mindoro, Mindanao, Basilan, and the Sulu Archipelago. The leaves are large, entire or lobed, dark green, and rough. The fruit is roundish, about the size of a child's head, thickly studded with upright blunt spines. The rind is thick and fleshy and contains a creamy white, sweet, juicy, and aromatic flesh of good taste. The large seeds may be roasted and eaten like peanuts. The maráng is one of the best "native" fruits of the Philippines.

CARISSA CARANDAS Linn. Plate 2, fig. 2.

A thorny shrub about 3 meters high or more, with long arching canes, native of India, from whence it was introduced several years ago. The white, fragrant, star-shaped flowers are followed by small clusters of ovoid to roundish black fruits about the size of a small cherry, with a subacid juicy pulp of pleasant taste. When green the fruit makes a good pickle, and when

[2] Wester, P. J., Bull. Philip. Bur. Agr. 39 (1925).

ripe it makes a fine jelly resembling grape jelly in color and taste.

The perunkila is very drought-resistant and is a promising fruit in regions with a long dry season. It makes an impenetrable live fence.

CUBILIA BLANCOI Blume. Kubíli. Plate 3, fig. 1.

A tree of medium size of wide distribution but not common in the Philippines. The leaves are pinnate. The fruits are roundish oblong, bright green and spiny, 5 to 6 centimeters long and contain a roundish-oblong brown nut about 3 centimeters long. The fruit is of excellent quality, roasted or boiled, and the tree deserves to be generally planted.

EUGENIA POLYCEPHALOIDES C. B. Rob. Lipoti. Plate 3, fig. 2.

A small tree, 9 meters high or more, native of Albay, Samar, and probably several adjoining provinces. The young growth is quadrangular. The leaves are oblong-obovate and pointed, leathery, dark green, and shining. The flowers are small and whitish. The fruits are roundish, black and shining, with white, rather dry and crisp flesh of pleasant acid taste, borne in clusters upon tubercles from the stem, twenty to fifty or more fruits to a cluster. They make a good jelly.

GNETUM INDICUM (Lour.) Merr. Bulso. Plate 4, fig. 2.

A large woody vine of wide distribution at low and medium altitudes. The leaves are elliptic to ovate and pointed, about 15 centimeters long. The small flowers are followed by grape-like bunches of brick-red, one-seeded fruits about 25 millimeters long. The large starchy seed is eaten raw or roasted. This vine has been domesticated at Lamao.

LUCUMA NERVOSA A. DC. Canistel. Plate 4, fig. 1.

A small, handsome tree, about 7 to 9 meters high, native of the West Indies. The leaves are oblanceolate to oblong-obovate and bright green, about 15 centimeters long. The fruit is roundish to ovoid, frequently pointed, 5 to about 8 centimeters long, yellow, with yellow, somewhat mealy, sweet and aromatic flesh, inclosing one to three large seeds.

The canistel was introduced into the Philippines in 1912 and has proved successful both in moist and periodically dry regions.

MANGIFERA CAESIA Jack. Baúno. Plate 5, fig. 1.

A tree of medium to large size, 15 to 30 meters high, with straight trunk and of majestic habit. The leaves are long and pointed, leathery and prominently veined. The fruit is oblong-

obovoid, somewhat larger than a mango, pale green, thin-skinned, and with white, somewhat fibrous, very aromatic and subacid flesh in which a large seed is embedded. It is a native of Malaysia; and probably was introduced into the Philippines, where it was naturalized long ago.

MANGIFERA sp. Mango amini. Plate 5, fig. 2.[3]

Fruit small; 170 to 250 grams in weight; roundish oblong, oblique, flattened; base flat; dorsal shoulder short and rounded; apex rounded, with a prominent, pointed swelling at neck; surface smooth, bright yellow, with a heavy red or scarlet black coloring extending sometimes over more than one-half of the fruits well exposed to the light, lenticels numerous, light yellow; bloom heavy; skin thick, tough, and adhering to the flesh; this rich yellow in color, firm, juicy, fiberless, of pleasing flavor and rather strong aroma; seed large and thick, constituting a larger portion of the fruit than in most varieties.

The tree is of vigorous growth, tall and open, prolific, and a regular bearer; the fruiting season is unusually long.

The other variety of Indian mango (Plate 6, fig. 1) analyzed together with the amini has not been identified. However, it is very similar to the amini in size, color, and taste.

MOMORDICA COCHINCHINENSIS (Lour.) Spreng. Tabolo. Plate 6, fig. 2.

A robust vine often 15 meters long, of wide distribution at low and medium elevations. The leaves are broadly ovate, entire or 3-lobed and pointed, 10 to 18 centimeters long. The fruits are roundish to short-oblong, about 12 centimeters long, yellow, with scattered short soft spines. The fruits are eaten immature and boiled as a vegetable in the Ilocos provinces.

MUSA sp. Bananas. Plates 7, 8, and 9, fig. 1.

The bananas called ideep, gensombaba, and katali are very similar to gloria ternate in appearance, size, and taste; while the petri and the toybok resemble the inarnibal. The analyses of these bananas are given in Table 2.

NEPHELIUM MUTABILE Blume. Bulala. Plate 9, fig. 2.

A tree about 15 meters high, of wide distribution in humid regions at low elevations in the Philippines and Malaya. The leaves are pinnate. The fruits are borne in loose terminal clusters. They are short-oblong, greenish to reddish brown, with coarse, erect spines. In the cultivated varieties the whitish flesh is subacid, juicy, and of excellent taste; it contains a large seed.

[3] Wester, P. J., Bull. Philip. Bur. Agr. **33** (1922).

There is an excellent variety grown in Jolo, but the bulala is rarely planted elsewhere.

RESULTS

The results recorded in Tables 1 and 2 are interesting since these Philippine fruits are rather rare and not commonly found in Philippine markets. Considerable difficulty was experienced in securing characteristic samples of these fruits and in getting them to Manila in good condition for analysis.

Analyses given in the tables show a high water content, which is characteristic of fruits in general. The bulso (*Gnetum indicum*) and kubili (*Cubilia blancoi*) fruits gave a high protein content. The atemoya (*Anona* sp.) mangoes, and maráng (*Artocarpus odoratissima*) showed a comparatively high sugar content. Although the fat content of fruits is usually very low, the kubili (*Cubilia blancoi*) and perunkila (*Carissa carandas*) gave a remarkably high fat content (ether extract). The kubili also contains the highest ash, indicating a high mineral content.

SUMMARY

Eighteen fruits, including five kinds of bananas, were analyzed. As a means of identification, botanical descriptions and photographs of these fruits are recorded. The composition and the calorific value of these fruits were determined.

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TABLE 1.—*Composition of some Philippine fruits.*

Name of fruit.	Average weight.	Weight of edible portion.	Moisture.	Ash.	Protein.	Sugars. Sucrose.	Sugars. Reducing.	Ether extract.	Crude fiber.	Acidity as acetic acid.	Other carbohydrates.	Calorific value per 100 grams.
	g.	*g.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Eugenia polycephaloides C. B. Rob.	5.1		87.25	0.41	0.78		2.77	1.51	1.56	2.13	3.59	49.71
Carissa carandas Linn.	4.9		83.73	0.85	1.16		9.65	2.24	1.15	.47	.75	72.94
Lacuma nervosa A. DC.	70.16	45.75	62.19	0.11	1.14		9.10	1.18	1.29		24.99	160.71
Nephelium mutabile Blume	29.30	6.0	84.54	0.45	0.82		8.20	0.55	0.14	0.64	4.66	61.78
Cubilia blancoi Blume	13.5		60.49	1.20	3.31			4.42	2.48		28.10	180.06
Mangifera caesia Jack	334.0		82.73	0.46	1.59		6.25	0.29	0.67	0.76	7.25	67.31
Artocarpus odoratissima Blanco	674.0		84.23	0.51	1.47	4.37	6.17	0.23	0.77	0.18	2.07	63.02
Gnetum indicum (Lour.) Merr.	4.5		45.06	1.35	3.96			0.12	1.14		48.37	220.34
Momordica cochinchinensis (Lour.) Spreng.	326.0	210	92.6	0.41	0.87		Trace	0.48	0.94		4.70	31.16
Artocarpus elastica Reinw.	260.00		84.11	0.63	1.62		7.24	0.37	0.92	0.30	4.81	63.26
Mango amini	195.0	72.0	79.72	0.42	0.83	11.21	5.90	0.25	0.61	0.96	.10	79.81
Mango, unidentified	189.5	68.0	79.74	0.50	0.33	7.42	6.45	0.31	0.48	0.30	4.47	81.40
Anona sp.	180.0	115.0	71.48	0.75	1.07	7.98	12.82	0.45	0.05		5.40	116.20

TABLE 2.—*Composition of some Philippine bananas.*

Name of fruit.	Average weight.	Weight of edible portion.	Mois-ture.	Ash.	Protein.	Sugars.		Ether extract.	Crude fiber.	Acidity as acetic acid.	Other carbo-hydrates.	Calorific value per 100 grams.
						Sucrose.	Reduc-ing.					
	g.	*g.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Bananas												
Petri	37.0	32.0	73.82	0.65	1.02	6.73	15.87	0.43	0.30	----	2.18	106.91
Toybok	52.0	36.0	70.89	0.83	1.04	5.32	17.42	0.25	0.26	----	3.99	117.25
Gensombaba	83.0	59.0	66.84	0.74	1.27	----	20.53	0.53	0.41	----	9.68	135.58
Katali	108.0	82.0	68.24	0.81	0.89	0.46	20.00	0.35	0.41	----	8.84	128.72
Ideep	81.0	51.0	69.83	0.89	1.03	9.08	14.41	0.34	0.32	----	4.10	121.82

ILLUSTRATIONS

PLATE 1

FIG. 1. *Anona* sp. Atemoya.
2. *Artocarpus elastica* Reinw. Gomihan.

PLATE 2

FIG. 1. *Artocarpus odoratissima* Blanco. Maráng.
2. *Carissa carandas* Linn.

PLATE 3

FIG. 1. *Cubilia blancoi* Blume. Kubíli.
2. *Eugenia polycephaloides* C. B. Rob. Lipoti.

PLATE 4

FIG. 1. *Lucuma nervosa* A. DC. Canistel.
2. *Gnetum indicum* (Lour.) Merr. Bulso.

PLATE 5

FIG. 1. *Mangifera caesia* Jack. Baúno.
2. *Mangifera* sp. Mango amini.

PLATE 6

FIG. 1. Mango (unidentified).
2. *Momordica cochinchinensis* (Lour.) Spreng. Tabolo.

PLATE 7

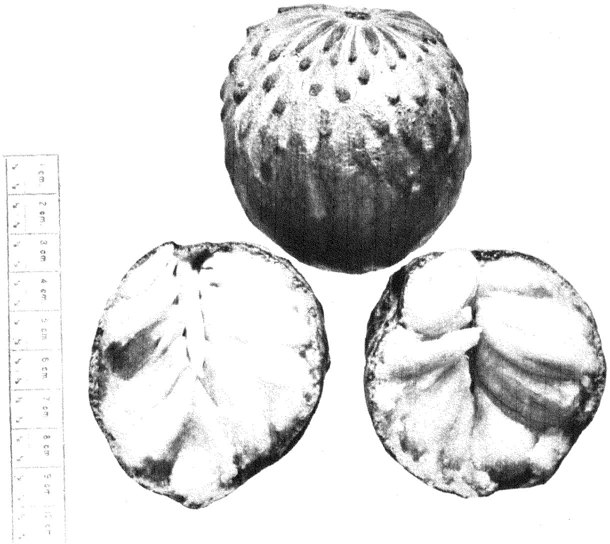
FIG. 1. *Musa* sp. Toybok.
2. *Musa* sp. Gensombaba.

PLATE 8

FIG. 1. *Musa* sp. Katali.
2. *Musa* sp. Ideep.

PLATE 9

FIG. 1. *Musa* sp. Petri.
2. *Nephelium mutabile* Blume. Bulala.



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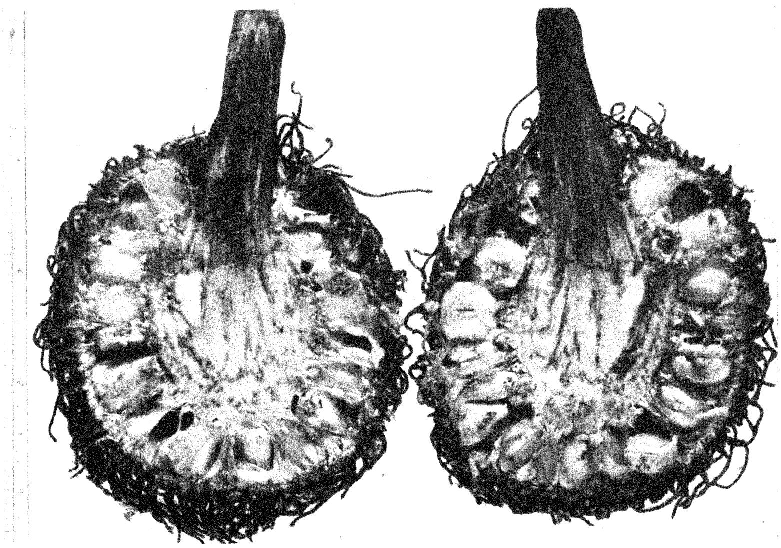

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Fig. 1. Anona sp.; 2. Artocarpus elastica.

PLATE 1.

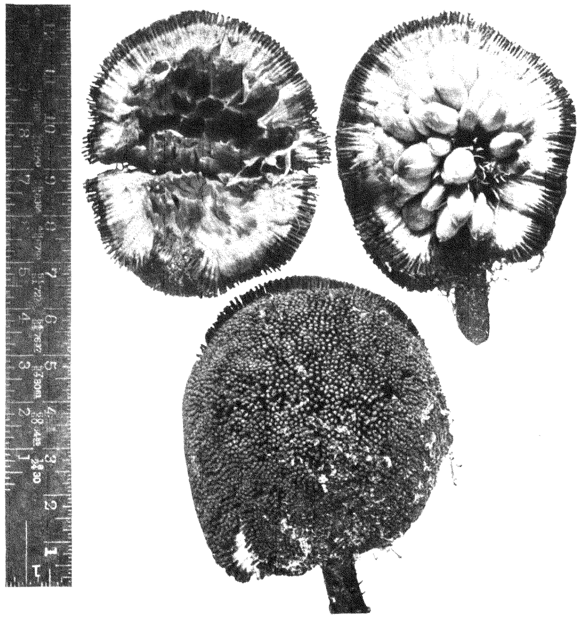

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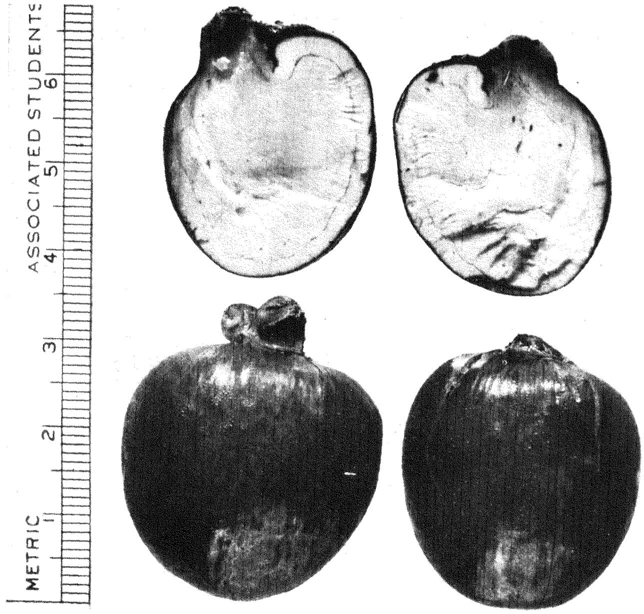
Fig. 1. Artocarpus odoratissima; 2. Carissa carandas.

PLATE 2.



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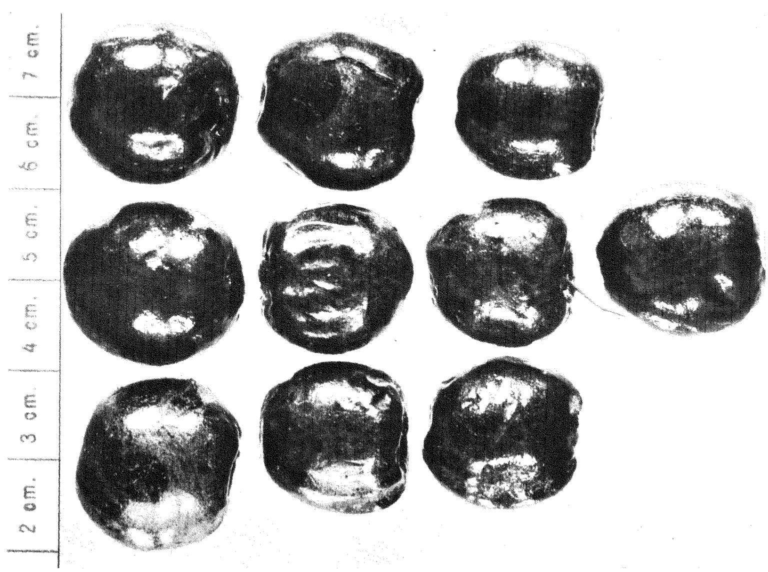

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Fig. 1. Cubilia blancoi; 2. Eugenia polycephaloides.

PLATE 3.

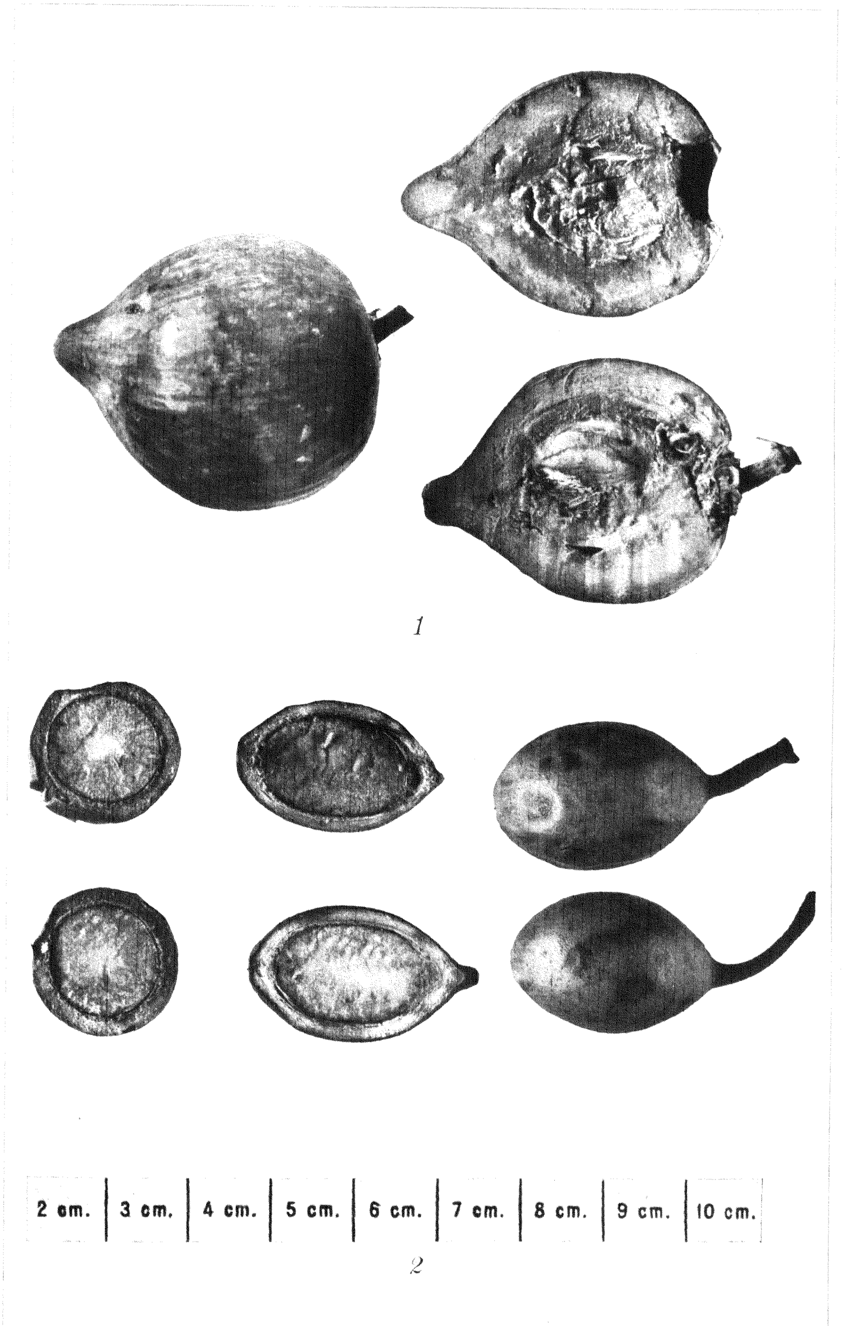

Fig. 1. Lucuma nervosa; 2. Gnetum indicum.

PLATE 4.

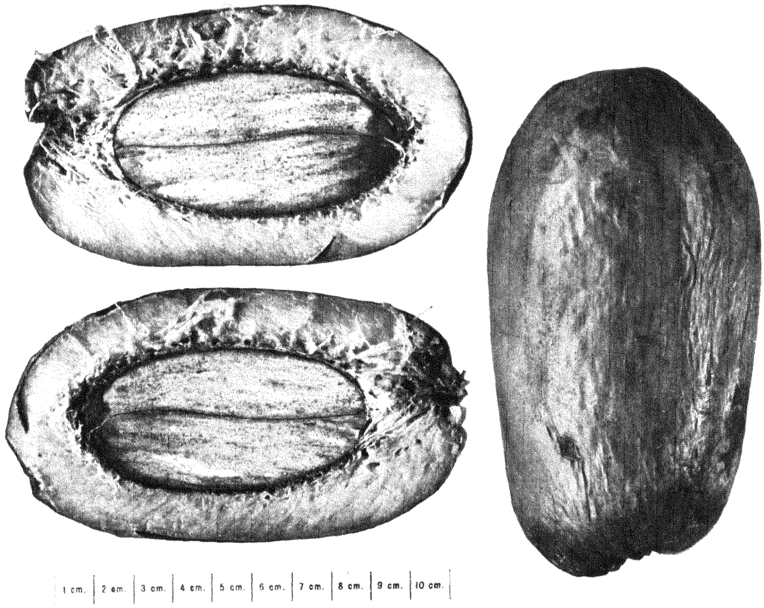

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Fig. 1. Mangifera caesia; 2. Mangifera sp.

PLATE 5.

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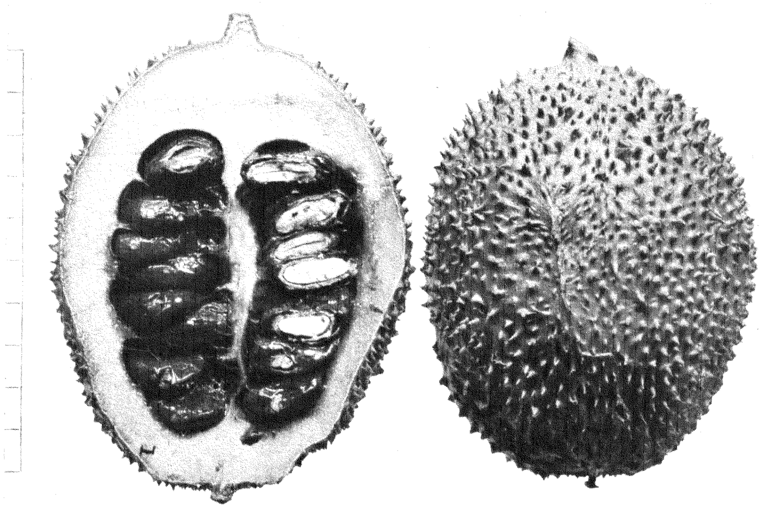

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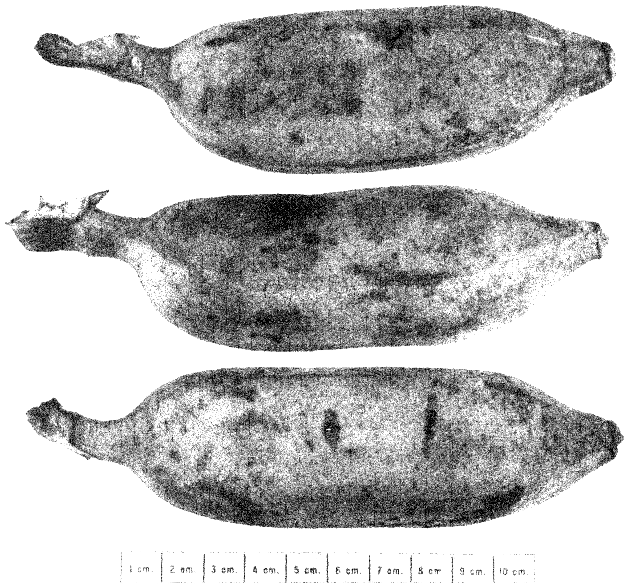
Fig. 1. Mango (unidentified); 2. Momordica cochinchinensis.

PLATE 6.

Fig. 1. Musa sp.; 2. Musa sp.

PLATE 7.



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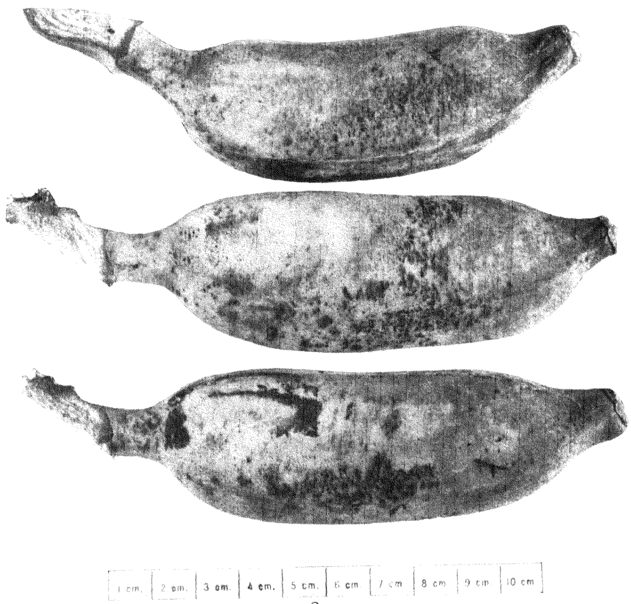

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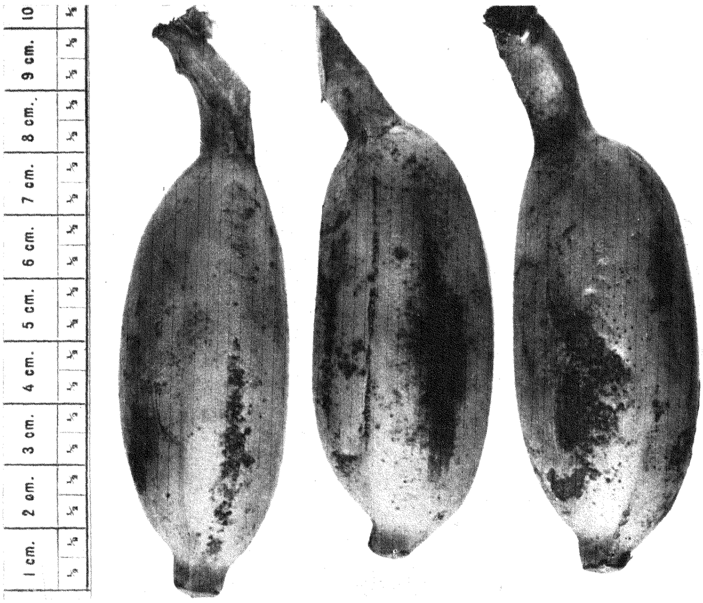
PLATE 8. MUSA SP.



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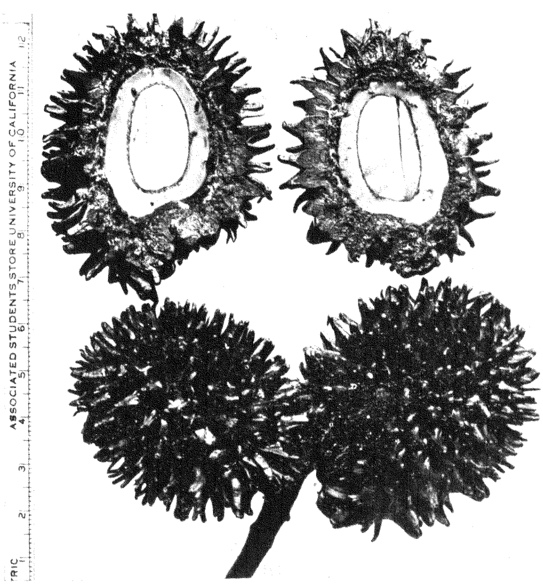

2

Fig. 1. Musa sp.; 2. Nephelium mutabile.

PLATE 9.

INDEX

[New names and new combinations are printed in **boldface**.]

A

Accipiter manillensis, 463.
Actitis hypoleucos, 463.
Adelphomyia, 521.
  issikina Alex., 508, 520, 521.
Aëdes ægypti, 629.
Ægialitis alexandrina, 463.
Æthiopsar cristatellus, 465.
Alapàpan, 62.
Alaudidæ, 465.
Alcedinidæ, 463.
ALEXANDER, CHARLES P., New or little-known Tipulidæ from the Philippines (Diptera), VII, 277; New or little-known Tipulidæ from eastern Asia (Diptera), VIII, 507.
Alkaloid from Anona reticulata Linn., 561.
Allamanda cathartica Linn., 477.
  hendersonii Bull., 477.
Allobosca, 538.
Alloeorhynchus bakeri Bergr., 419.
  pulchellus Stål, 417.
  vinulus Stål, 417.
Alloeorrhynchus **bakeri** Harris, 417.
  vinulus Reuter & Poppius, 417.
Amáras, 110.
Amomoslo, 38.
Ampullaria, 476.
Anacardiaceæ, 477.
Analysis and food value of some unusual Philippine fruits, 655.
Anomala leotaudi Blanch., 557.
  muricata Ohaus, 556.
  nocturna Ohaus, 557.
  ovatula Ohaus, 556.
Anona, 561.
  muricata Linn., 561.
  reticulata Linn., 561, 562; alkaloid from, 561.
  squamosa Linn., 561.
  sp., 656, 659, 660.
Anopheles aconitus Donitz, 248–258, 260.
  aconitus var. **filipinæ** Manalang, 258, 260.
  braziliensis, 255.
  febrifer Banks, 247, 248.
  febrifera, 247.
  flavirostris Ludlow, 247.
  funestus Giles, 247, 248, 255, 258–260.
  funestus listoni, 256.
  funestus var. aconitus, 248, 249, 256, 258.
Anopheles—Continued.
  funestus var. listoni, 256.
  funestus var. minimus, 248, 259.
  mangyana Banks, 247.
  minimus Theobald, 247–260, 474.
  minimus var. varuna Christophers, 260.
  novumbrosus, 259.
  similis, 259.
  strodei, 255.
  tessellatus, 474.
  vagus Donitz, 249, 474.
  varuna Iyengar, 260.
Antitreponematous vaccine therapy, immunologic effect of, administered after specific treatment which was given in the early stage of initial local yaws in Philippine monkeys, 603.
  immunity, duration of, with regard to syphilis in Philippine monkeys, 595.
  immunity, duration of, in Philippine monkeys originally conveyed by immunization with killed yaws vaccine, 599.
Antocha styx, 518.
  (Antocha) bifida Alex., 508.
  (Antocha) **styx** Alex., 508, 517.
Apis binghami Ckll., 265.
Apocynaceæ, 477.
Ardeidæ, 463.
Aristonabis reuteri Berg., 415.
Artabotrys suaveolen, Blm., 561.
Artocarpus communis Forst., 478.
  cumingiana Trec., 478.
  elastica Reinw., 656, 660.
  integra (Thunb.) Merr., 478.
  odoratissima Blco., 656, 659, 660.
Asclepiadaceæ, 477.
Asclepias syriaca, 477.
Atarba (Atarbodes) fuscicornis Edw., 508.
  (Atarbodes) leptoxantha Alex., 508.
  (Atarbodes) pallidicornis Edw., 508.
Atemoya, 656, 659.

B

Bacillus bovisepticus, 573, 575.
  tuberculosis, 577.
Bagaybajon, 62.
Balai, 19.
Balantidium, 458, 470, 472, 474.
  blattarum, 474.
  caviae, 460.
  coli, 453, 456–458.
  haughwouti de Leon, 476.
  suis, 458.

Baligágod, 181.
Bananas, 658.
Barágit, 42.
Barred ground dove, 463.
Baúno, 657.
Bayag-bayág, 19.
Bayóng-ukaí, 74.
Black-chinned fruit pigeon, 463.
Blatella germanica, 476.
  lapponica, 476.
Bolbopsittacus lunulatus, 463.
Boyo-bóyo, 110.
Brachypteromyia, 547.
Broad-billed roller, 463.
Bubulcus coromandus, 463.
Bucerotidæ, 464.
Bufo melanostictus, 471.
Bulala, 658.
Bulso, 657, 659.
Busok-búsok, 172.
Buyat-halo, 53.
Buyo, 89.
  de anis, 89, 193.
Buyo-anís, 89.
Buyo-bóyo, 181, 182.
Buyo-buyo, 62, 89, 113.
Buyo-halo, 62.
Buyo-háyo, 82.
Búyog, 42, 89.
Buyog-halas, 154.
Buyok, 89.
Buyok-buyok, 39, 172.
Buyók-hálo, 130.
Buyong-amo, 62.
Buyong-sinhalo, 64.
Buyu, 89.

C

Cabanis's weaver, 465.
Calotropis gigantea (Linn.) Dryand., 477.
Campanulaceæ, 477.
Campophagidæ, 464.
Canistel, 657.
Carbohydrate and serological determinations of the bipolar gas-forming and non-gas-forming organisms isolated from lymph glands of slaughtered cattle, 565.
Carica papaya Linn., 477.
Caricaceæ, 477.
Carissa carandas Linn., 656, 659, 660.
Centropus javanicus, 464.
Cepedea, 471.
Cephalophoneus nasutus, 464.
Charadriidæ, 463.
Chavica benthamiana Miq., 99.
  betle Miq., 85.
  celtidiformis Miq., 177.
  chaba Miq., 58.
  corylistachya Miq., 177, 179.
  densa Miq., 90.
  lessertiana Miq., 36, 38.
  majuscula Miq., 45.
  miniata Miq., 20.
Chavica—Continued.
  miniata Miq. var. hirtella Miq., 23.
  officinarum Miq., 107, 110.
  parvifolia Hassk., 107.
  populifolia Miq., 58, 61.
  ? retrofracta Miq., 107.
  sarmentosa Miq., 101.
  siriboa Miq., 85.
  ? viminalis Miq., 126.
Chilomastix, 468, 473.
  bettencourti, 461.
  cuniculi, 459.
  gallinarum, 468.
  intestinalis, 460.
  mesnili, 456, 457.
Chlostridium tetani, 624.
Chrysophyllum cainito Linn., 478.
CHU, H. J. *see* HEGNER and CHU.
Cinnamomum, 305, 306, 317.
  burmanii Blm., 306–308, 324, 347, 348, 350, 351, 353–357.
  burmanni Blm. var. angustifolium, 348.
  burmanni Blm. var. chinense, 306, 348.
  camphora Nees & Eberm., 307.
  cassia Blm., 306–308, 317, 318, 320, 321, 326–329, 336, 338, 339, 346, 353–356.
  iners Reinw., 306, 308, 341, 342, 344, 353–356.
  mercadoi Vid., 306–308, 331, 336, 338, 346, 353–356.
  microphyllum, 306.
  mindanaense Elm., 306–309, 325, 326, 328, 329, 331, 336, 338, 342, 348–356.
  myrianthum Merr., 306.
  sandkuhlii Merr., 306.
  trichophyllum, 306.
  zeylanicum Blm., 306–309, 318–321, 323, 325–331, 333–336, 339, 341–344, 353–356.
Cinnamon bittern, 463.
  trees, leaf and bark structure of, 305.
Circus sp., 552.
Coccobryon, 2, 64.
COCKERELL, T. D. A., The xylocopid or carpenter bees of the Philippine Islands, 265.
Collocalia marginata, 464.
  troglodytes, 464.
Common sandpiper, 463.
Convolvulaceæ, 477.
Coraciidæ, 463.
Corone philippina, 465.
Corvidæ, 465.
Crataerina von Olfers, 547, 549.
  acutipennis Austen, 549.
  lonchoptera von Olfers, 547.
  longipennis Austen, 549.
  obtusipennis Austen, 549.
Crested myna, 465.
Cryptolabis aliena (Alex.), 529.
  funebris (Alex.), 529.
  (Baeoura) **trichopoda** Alex., 528.
  trichopeda, 529.

Cubeba canina Miq., 120.
Cubilia blancoi Blm., 657, 659, 660.
Cuculidæ, 464.
Cyclemys amboinensis, 470.
Cylindrotominæ, 285.
Cynocephalus volans, 462.
Cypselus affinis, 549.
Cytamœba, 470.

D

Dagóg, 172.
Dama-dama, 374, 399.
Danód, 172.
Dasymallomyia rignata Brun., 509.
Dawn-sha-atab, 56.
Dicranoptycha, 519.
 issikina Alex., 508, 518.
Dicranota (Amalopina) **delectata** Alex., 508, 519, 520.
 (Amalopina) dicranotoides (Alex.), 520.
 (Amalopina) gibbera (Alex.), 508.
 (Amalopina) **gibbera** (**Alex.**) var., **523**.
 (Amalopina) sibirica (Alex.), 520.
Dientamœba fragilis, 456, 457.
Dijarán, 19.
Diptera pupipara from the Philippine Islands, 537.
Dischidia ruscifolia Decne., 477.
 vidalii Becc., 477.
Discobola, 512.
Dodonaeus humeralis Dist., 422.
Dolichopeza, 282, 507.
 malagasya Karsch, 282.
 (Dolichopeza) **isolata** Alex., 282.
 (Nesopeza) **tarsalba** Alex., 509, 510.
 (Nesopeza) tarsalis (Alex.), 509, 510.
 (Oropeza) bispinula (Alex.), 511.
 (Oropeza) **saitamensis** Alex., 510, 511.
 (Oropeza) shirakiella (Alex.), 507.
Dumá-dínayan, 82.
Dumadingan, 141.
Dúut, 32.

E

Eastern swallow, 464.
Echestypus, 538, 547.
Edolisoma caerulescens, 464.
Eimeria, 462, 468, 469.
 avium, 468.
 caviae, 460.
 perforans, 459, 460.
 pfeifferi, 468.
 stiedae, 459.
Elephantomyia (Elephantomyia) serotina Alex., 508.
 (Elephantomyodes) uniformis Alex., 508.
Embadomonas, 457, 460.
 cuniculi, 459.
 intestinalis, 456.
Endamœba, 468, 470, 474, 475.
 blattae, 474–476.
 cobayae, 460.
 coli, 453, 456, 457.
 cuniculi, 459.
Endamœba—Continued.
 gallinarum, 468.
 gingivalis, 457.
 histolytica, 453, 456, 457.
 muris, 461.
 ranarum, 472.
 thomsoni, 474, 475.
Endolimax, 468, 474.
 blattae, 474.
 caviae, 460.
 gregariniformis, 468.
 nana, 453, 456, 457.
 ranarum, 472.
Enteromonas intestinalis, 459.
Epiphragma bakeri Alex., 294.
 crenulata Alex., 293, 294.
 divisa Alex., 508.
 ochrinota Alex., 294.
Erioptera (Empeda) **lituputina** Alex., 509, 530, 531.
 (Empeda) minuscula Alex., 509.
 (Empeda) **sulfureoclavata** Alex., 529, 530.
 (Ilisia) tenuisentis Alex., 509.
Eriopterini, 295, 523.
Euchlora ceramopyga Ohaus.
 nerissa Ohaus, 558.
Eugenia polycephaloides C. B. Rob., 657, 660.
Euglenamorpha, 473.
 hegneri, 471.
Euphorbia heterophylla Linn., 478.
 hirta Linn., 477, 478.
 pilulifera, 476.
 pulcherrima Willd., 478.
 splendens Boj., 478.
 tirucalli Linn., 478.
 trigona Haw., 478.
Euphorbiaceæ, 478.
Eupiper, 2, 7, 19, 64, 66.
Eurystomus, 551.
 orientalis (Linn.), 463, 551.
Experimental studies of the treatment of surra, 627.

F

Falconidæ, 463.
Famsaon, 71.
FAUSTINO, LEOPOLDO A., Notes on Mayon Volcano, 501.
Ferris, G. F., Sixth report upon Diptera pupipara from the Philippine Islands, 537.
Ficus elastica Roxb., 478.
 hauili Blco., 478.
 minahassae (Teysm. & De Vr.) Miq., 478.
 nota (Blco.) Merr., 478.
 religiosa Linn., 478.
Frambœsia tropica, 433.
FRANCISCO, ANACLETO D., and P. J. WESTER, Analysis and food value of some unusual Philippine fruits, 655.
Funereal woodpecker, 464.

G

Gallinago stenura, 463.
chloropus, 463.
Gamocystis tenax, 476.
Ganed, 56.
Ganid, 56.
Gáoed, 89.
GARCIA, ONOFRE, Carbohydrate and serological determinations of the bipolar gas-forming and non-gas-forming organisms isolated from lymph glands of slaughtered cattle, 565.
Gáued, 89, 119.
Gensombaba, 661.
Geopelia striata (Linn.), 463, 550.
Giardia, 453, 455, 458, 460, 463, 469, 473.
agilis, 471.
canis, 459.
caviae, 460.
duodenalis, 459.
lamblia, 457.
muris, 461.
Gnetum indicum (Lour.) Merr., 657, 659, 660.
Gnophomyia confluenta Alex., 523.
Gók, 89.
Gomihan, 656.
Gonomyia bicolorata, 297.
(Gonomyia) **nansei** Alex., 509, 524.
(Lipophleps) **bicolorata** Alex., 295.
(Lipophleps) gracilis Skuse, 526.
(Lipophleps) hackeri Edw., 297.
(Lipophleps) longiradialis Alex., 526.
(Lipophleps) **neonebulosa** Alex., 509, 526.
(Lipophleps) robinsoni Edw., 527.
(Lipophleps) **sauteri** Alex., 525, 526.
(Lipophleps) **sinuosa** Alex., 527, 528.
(Lipophleps) skusei Alex., 526.
(Lipophleps) sulphurella, 528.
(Progonomyia) confluenta (Alex.), 509, 523.
(Progonomyia) scutellum-album Alex., 524.
Gorpis Stål, 421.
acutispinis Reuter, 421.
albicans Reuter, 421.
annulatus Paiva, 421.
apicalis Reuter, 422.
cincticrus Reuter, 422.
cribraticollis Stål, 421, 422.
elegans Poppius, 422.
flavicans Harris, 420, 422.
humeralis (Dist.), 422.
philippinensis Harris, 420, 422.
rufinervis Poppius, 422.
sordida Reuter, 419.
sordidus Poppius, 419, 420.
sordidus Reuter, 419, 422.
subtilis Reuter, 422.
transvaalensis Schouteden, 422.
(Dodonaeus) humeralis Reuter, 422.
Gray-backed coleto, 465.
starling, 465.
Gray-headed shrike, 464.
Green-headed bee-bird, 464.
Gregarina blattarum, 476.
serpentula, 476.
Guava bulbul, 464.
Gumba, 19.
Gutí-gutí, 62.

H

Haemoproteus, 452, 463–466.
columbae, 466.
Halcyon chloris, 463.
coromandus, 463.
gularis, 463.
lindsayi, 463.
Haliastur intermedius, 463.
Halopái, 51, 62.
Halteridium, 465.
HARRIS, HALBERT M., Notes on Philippine Nabidæ, with a catalogue of the species of Gorpis (Hemiptera), 415.
Heckeria, 7, 17.
subpeltata Kunth, 17.
HEGNER, ROBERT, and H. J. CHU, A survey of Protozoa parasitic in plants and animals of the Philippine Islands, 451.
Helius argyrosterna, 291.
(Eurhamphidia) inelegans Alex., 518.
(Eurhamphidia) **perelegans** Alex., 508, 518.
(Helius) **argyrosterna** Alex., 290.
(Helius) attenuatus Alex., 508.
Hemiprocne comata (Temm.), 551.
Hepatozoon, 465.
Herpetomonas, 473.
muscae domesticae, 473.
Hexamita, 457, 470, 472, 475.
muris, 461.
periplanetae, 474, 475.
Hexatomini, 293, 521.
Hippobosca Linn., 537, 538.
camelina Leach, 542, 544.
canina Rondani, 539.
capensis von Olfers, 539, 541.
dromedarina Speiser, 544.
equina Linn., 538, 539, 541, 544.
francilloni Leach, 539.
maculata Leach, 538, 542, 544.
rufipes von Olfers, 544.
Hirundinidæ, 464.
Hirundo gutturalis, 464.
Hydnocarpus alcalæ C. DC., 409.
Hydrosaurus pustulosus, 470.

I

Ianahon, 149.
Ideep, 661.
Ihaláson, 47.

Íkmo, 89.
Íkmong-ilóko, 89.
Ikmong-uák, 157.
Immunologic effect of repeated yaws infections interrupted by specific treatment given in the early stage of initial yaw, 589.
Indian cattle egret, 463.
Iodamœba, 457.
williamsi, 456.
Iole gularis, 464.
Ipomoea batatas (Linn.) Poir., 477.
cairica (Linn.) Sweet, 478.
fistulosa Mart., 478.
reptans (Linn.) Poir., 478.
Isospora, 469.
felis, 455.
hominis, 455.
Isotoma longiflora (Mill.) Presl., 477.
Ítmo, 89.
Ixobrychus astrologus Wetmore, 552.
cinnamomeus, 463.
sinensis, 463.

J

Jatropha curcas Linn., 478.
Java sparrow, 465.
coucal, 464.
Juan, 103.

K

Kadákad, 157.
Kaláat, 157.
Kaláscas, 160.
Kalaskás, 157.
Kaligu-uan, 62.
Kaliñgag, 332.
Kaloula picta, 472.
Kamámba, 19.
Kamára, 110.
Kángal, 117.
Kanisi, 89.
Katali, 661.
Kayungo, 110.
Kentish plover, 463.
Koptorthosoma Grib., 269.
Kubámba, 19.
Kubánbang-damó, 19.
Kubili, 657, 659.
Kúyo, 19, 45.
Kúyok, 19.

L

Laiñgan, 62.
Lakbaugan, 117.
Lalage niger, 464.
Lambu-lambú, 228.
Laniidæ, 464.
Large-billed pigmy woodpecker, 464.
Large-nosed shrike, 464.
Laridæ, 463.
Lauigang, 62.
Lauiñgan, 22, 105, 117, 130.
Lauiñgan-ihalas, 130.
Lead and copper, occlusion of, in nonferrous alloys by metastannic and metantimonic acids, 403.
Leaf and bark structure of some cinnamon trees with special reference to the Philippine species, 305.
Leprosy, cultivation of an acid-fast Bacillus from, 577.
Leucocytozoon, 465.
Leucotreron leclancheri, 463.
Libnotes, 287.
Lichtensteinipicus funebris, 464.
Limnophila nigronitida Edw., 522.
(Dicranophragma) formosa Alex., 508.
(Dicranophragma) taiwanensis Alex., 508.
(Prionolabis) liponeura Alex., 522.
(Prionolabis) lipophleps Alex., 522.
(Prionolabis) **serridentata** Alex., 508, 521, 522.
Limonia koxinga, 513.
luteivittata, 288.
multinodulosa, 290.
(Dicranomyia) depauperata (Alex.), 508.
(Dicranomyia) fullowayi (Alex), 516.
(Dicranomyia) nesomorio (Alex.), 508.
(Dicranomyia) punctulata (de Meij.), 515, 516.
(Dicranomyia) sordida (Brun.), 508.
(Dicranomyia) **subpunctulata** Alex., 508, 515, 516.
(Discobola) argus (Say), 511, 512.
(Discobola) margarita (Alex.), 507.
(Discobola) **taivanella** Alex., 507, 511, 512.
(Geranomyia) alpestris Alex., 508.
(Geranomyia) **apicifasciata** Alex., 516, 517.
(Geranomyia) **phœnaspis** Alex., 290.
(Libnotes) **acrophæa** Alex., 287.
(Libnotes) **carbonipes** Alex., 286, 287.
(Libnotes) **hassenana** Alex., 508, 514.
(Libnotes) riverai Alex., 514.
(Libnotes) termitina (O. S.), 287.
(Limonia) alticola (Edw.), 513.
(Limonia) curvispina Alex., 507.
(Limonia) ebriola Alex., 507.
(Limonia) flavoterminalis Alex., 507.
(Limonia) fraudulenta Alex., 507.
(Limonia) **koxinga** Alex., 507, 512.
(Limonia) **luteivittata** Alex., 287.
(Limonia) **multinodulosa Alex.,** 288.
(Limonia) remissa Alex., 508.
(Rhipidia) formosana (Alex.), 508.
(Rhipidia) maculata (Meig.), 515.
(Rhipidia) **triarmata** Alex., 508, 514, 515.
Limoniinæ, 286, 511.
Limoniini, 286, 511.
Lindsay's kingfisher, 463.
Lingolingo-daytoi, 62.
Lipophleps, 527.

Lipoptena Nitzsch, 538, 546.
cervi (Linn.), 546.
gracilis Speiser, 547.
subulata Coq., 546.
traguli Ferris & Cole, 547.
sp., 547.
Lipoti, 657.
Litlit, 82, 110, 113, 157, 160, 180.
Litlít-aníto, 101, 180, 181.
Litlít-áso, 160.
Litlít-báboy, 181.
Litlít-kalabau, 117.
Litlít-kauáyan, 157.
Litlít-kayakas, 141.
Litlít-matsing, 32, 82, 130, 181, 182.
Little yellow bittern, 463.
Lophomonas blattarum, 474, 475.
striata, 474, 475.
Loriculus bournsi McG., 551.
Lucuma nervosa A. DC., 657, 660.
Luzon cuckoo shrike, 464.
guaiabero, 463.
tarictic, 464.
Lynchia Weyenbergh, 552.
maura, 466.
sarta (Ferris), 552.
setosa Ferris, 552.

M

Mabuya multicarinata, 470.
Makago, 117.
Malapágba, 42.
Malayan Brahminy kite, 463.
Malisa, 169.
Mamin, 89.
Mamon, 89.
MANALANG, C., Morphology and classification of the Philippine variety of Anopheles aconitus Donitz, 1902, and Anopheles minimus Theobald, 1901, 247.
Mandásai, 141.
Mangifera caesia Jack, 657, 660.
indica Linn., 477.
sp., 658.
Mango amini, 658, 660.
Mangolas, 24.
Manihot utilissima Pohl, 478.
Manikatápai, 38, 62, 117, 131, 141, 161.
Manikatápi, 79.
Maniniak, 76.
Manlakbayan, 22.
Mapoua, 82.
Maragum, 119.
Maraklít-salusalú, 74.
Maráng, 656, 659.
Margaritifera margaritifera Linn., 498.
maxima Jameson, 488, 498.
Mayon Volcano, 501.
Melania blatta Lea, 476.
Melanolepis multiglandulosa (Reinw.) Reichb. f. & Zoll., 478.
Melophagus Linn., 538, 545.
ovinus Linn., 545, 546.
Meropidæ, 464.
Merops philippinus, 464.
Mesotrichia Westw., 265, 266, 268, 269.
adusta (Pérez), 272.
amauroptera (Pérez), 270, 274.
bakeriana Ckll., 270, 274.
bilineata (Fr.), 273.
blüthgeni (Dusmet), 272, 273.
bombiformis Sm., 269, 271, 274, 275.
caffra (Linn.), 265.
canaria Ckll. & LeVeque, 270, 272.
ceballosi (Dusmet), 274.
chlorina (Ckll.), 273, 274.
clavicrus Maidl, 269.
confusa (Pérez), 270, 271.
cuernosensis Ckll., 265, 270, 271.
dapitanensis Ckll., 271, 274.
diversa (Klug), 265.
euchlora (Pérez), 269, 270.
flavorufa (DeG.), 265.
ghilianii (Grib.), 270–272.
latipes (Drury), 268, 269.
latipes basiloptera Ckll., 269.
lucbanensis Ckll., 272.
maesoi (Dusmet), 274.
major (Maidl), 269.
major (bombiformis), 270.
mixta (Radoszkowski), 265.
nigroplagiata (Ritsema), 271.
occipitalis (Pérez), 272.
philippinensis (Sm.), 265, 270, 271, 273.
philippinensis chlorina Ckll., 270.
philippinensis samarensis, 270, 274.
philippinensis **tayabanica** Ckll., 273.
samarensis Ckll. & LeVeque, 273, 274.
senior (Vachal), 265.
subvolatilis Ckll., 269.
tambelanensis Ckll., 271.
tenuiscapa (Westw.), 268.
tricolor (Ritsema), 271, 275.
trifasciata (Grib.), 265, 271–273.
vachali (Pérez), 269, 270.
volatilis Sm., 269.
Miaukau, 79.
Microhierax erythrogenys, 463.
meridionalis Grant, 552.
Micropiper exiguum Miq., 219.
laevifolium Miq., 207.
pellucidum Miq., 218.
tenellum Klotz., 218.
Micropodidæ, 464.
MIYAO, ISAO, An inquiry into the so-called latent infection in yaws-vaccinated monkeys as a possible result of the test for immunity by intradermal inoculation with living yaws material, 425; Immunologic relation between three Philippine strains of yaws, 429; Is Framboesia tropica a nosologic entity?, 433.
Molophilus arisanus Alex., 509.
nigritus Alex., 509.
Momordica cochinchinensis (Lour.) Spreng., 658, 660.

Mongoma Westw., 297.
Moorhen, 463.
Moraceæ, 478.
Morphology and classification of the Philippine variety of Anopheles aconitus Donitz, 1902, and Anopheles minimus Theobald, 1901, 247.
Morus alba Linn., 478.
Motacillidæ, 465.
Mountain sparrow, 465.
Muldera, 7, 173.
baccata Miq., 173.
MUNDO, SALVADOR DEL, The occlusion of lead and copper in nonferrous alloys by metastannic and metantimonic acids, 403.
Munia cabanisi, 465.
jagori, 465.
Musa sp., 658.
Myiophthiria Rondani, 547, 548, 550.
lygaeoides, 549.
reduvioides Rondani, 549, 550.
(=Brachypteromyia) fimbriata (Waterh.), 549.
Myzomyia funestus Giles, 247.
rossi mangyana Banks, 247.

N

Nabis tagalicus Reuter, 419.
tagalicus Stål, 419.
Nachtrag zur kenntnis der philippinischen Ruteliden (Coleoptera, Lamellicornia), VI, 555.
Naphthol esters of chaulmoogric acid and chaulmoogryl naphthylamines, 409.
Nauphoeta cinerea, 475.
Neolimnophila alticola Alex., 508.
Nephelium mutabile Blm., 658, 660.
Nesopeza **angustaxillaris** Alex., 284, 285.
annulitarsis Alex., 283–285.
cinctitarsis Alex., 284, 285.
Nipponomyia symphyletes (Alex.), 508.
Northern white-eared pigeon, 463.
Nyctomelitta Ckll., 266.
Nyctotherus, 470.
ovalis, 474, 475.

O

OHAUS, F., VI. Nachtrag zur Kenntnis der philippinischen Ruteliden (Coleoptera, Lamellicornia), 555.
Olasiman-ihalas, 219.
Oncopeltus fasciatus, 477.
Opalina, 470, 471, 473.
Opoi, 22.
Orimarga, 292.
perpictula Alex., 291.
pictula Edw., 292, 293.
Oriolidæ, 465.
Oriolus acrorhynchus, 465.
Ormosia aculeata, 532.
anthracopoda Alex., 509, 531, 532.
Ornitheza Speiser, 551.
metallica (Schiner), 551.
Ornithoica Rondani, 551.
confluenta (Say), 551.
promiscua Ferris & Cole, 551.
pusilla (Schiner), 551.
Ornithomyia Latr., 552.
avicularia (Linn.), 552.
pallida Latr., 547.
Ornithoponus sartus Ferris, 552.
Ortholfersia, 538.
Osmotreron axillaris, 463.
Otomela lucionensis, 464.
Ottonia, 190.
Oxydiscus de Meij., 521.

P

Padda oryzivora, 465.
Palay-butó, 113.
Paler palm swift, 464.
Paminta, 157, 169.
Pamipamintahan, 157.
Paragreenia, 265, 266.
Paramongoma Brun., 297.
Parastasia nigroscutellata Ohaus, 555.
Parong, 22, 24, 53, 106.
Parong-dagkó, 188.
Passer montanus, 465.
Pasteurella, 574.
Patai-patai, 62.
Pearl fisheries of Sulu, 483.
Pediciini, 519.
Pediculus cervi Linn., 546.
Pedilanthus tithymaloides Poir., 478.
Penelopidis manillae, 464.
Penninervia Quis., 1, 6, 7, 66, 176.
Peperomia Ruiz & Pavon, 1, 3, 4, 7, 194, 198.
agusanensis C. DC., 195, 210.
apoana C. DC., 207, 209.
argyreia Morren, 5, 228.
bilineata (Blm.) Miq., 213, 230.
canlaonensis C. DC., 195, 200, 201.
copelandii Quis., 195, 201.
dindygulensis Miq. forma macilenta Miq., 205, 206.
elmeri C. DC., 6, 195, 216.
exigua (Blm.) Miq., 194, 213, 219, 228.
hymenophylla Miq., 218, 219.
laevifolia (Blm.) Miq., 195, 207, 209, 211.
lagunaensis C. DC., 195, 206.
lanaoensis C. DC., 194, 226, 228.
latibracteata Quis., 196, 224.
macgregorii C. DC., 225, 226.
mariannensis C. DC., 230.
marivelesana C. DC., 196, 220, 224.
membranacea Hook. & Arn., 230.
merrillii C. DC., 194, 209, 212.
mindorensis C. DC., 195, 215.
negrosensis C. DC., 195, 213, 216.
pallidibacca C. DC., 195, 199, 200, 216.
pauaiana C. DC., 4, 225, 226.
pellucida (Linn.) HBK., 4, 194, 206, 218.

Peperomia—Continued.
pellucidopunctulata C. DC., 195, 206, 209.
puberulifolia C. DC., 206.
ramosii C. DC., 4, 199, 200.
recurvata, 5.
recurvata (Blm.) Miq. forma longispica C. DC., 205.
recurvata (Blm.) Miq. var. longispica C. DC., 195, 205, 206.
recurvata (Blm.) Miq. var. pilosior C. DC., 195, 203, 205, 206.
reflexa, 4, 7.
reflexa A. Dietr. forma capensis Miq., 196.
reflexa A. Dietr. forma subsessilifolia C. DC., 196, 198.
reflexa A. Dietr. var. calcicola C. DC., 196–198.
reflexa A. Dietr. var. capensis, 198.
reflexa (Linn. f.) A. Dietr. forma parvilimba C. DC., 198.
reflexa (Linn. f.) A. Dietr. var. capensis (Miq.) C. DC., 196.
reflexa (Linn. f.) A. Dietr. var. parvilimba C. DC., 196, 198.
rivulorum C. DC., 195, 226, 228.
rubrivenosa C. DC., 195, 222, 225, 226.
tomentosa, 5.
tomentosa (Vahl) A. Dietr. var. carnosa Miq., 196, 222, 225.
vanoverberghii C. DC., 4, 205.
ventenatii Miq., 200, 201, 203.
Periplaneta americana, 474–476.
orientalis, 476.
Perunkila, 659.
Petri, 661.
Phapitreron leucotis, 463.
Pharmacum magnum vulgare Rumph., 107, 110.
Philippine bulbul, 464.
crow, 465.
falconet, 463.
fruits, 655.
green pigeon, 463.
Nabidæ, 415.
oriole, 465.
Piperaceæ, 1.
sparrow hawk, 463.
weaver, 465.
Phorticus **variegatus** Harris, 415.
Phyllanthus reticulatus Poir., 478.
Phytomonas, 476, 477.
elmassiani, 477.
Picidæ, 464.
Pied chat, 464.
lalage, 464.
Pigmy swiftlet, 464.
Pimienta, 169.
Pintail snipe, 463.
Piper Linn., 1, 3, 4, 7, 8, 19, 58.
abbreviatum Opiz, 5, 6, 13, 58, 60, 64.
abraense C. DC., 157.
acre Blm., 160.
acutibaccum C. DC., 15, 146.

Piper—Continued.
agusanense C. DC., 9, 50.
albidirameum C. DC., 13, 113, 115, 117, 119, 192.
allenii C. DC., 101, 103.
amboinense C. DC., 190.
angustipeltatum Merr., 8, 98.
anisodorum Blco., 85.
anisumolens Blco., 85.
apoanum C. DC., 14, 131–133.
arborescens Roxb., 5, 6, 9, 20, 22, 26, 30, 32, 34, 49.
arborescens Roxb. var. **angustilimbum** Quis., 9, 22.
arborescens Roxb. var. hirtellum (Miq.) Merr., 9, 23, 25.
arborisedens C. DC., 14, 145, 147, 148.
arcuatum Blm., 190.
aristolochiphyllum Quis., 8, 54.
asterostigmum Quis., 13, 91.
atrospicum C. DC., 10, 71.
attenuatum Wall., 191.
aurilimbum C. DC., 5, 9, 55.
baccatum Blm., 5, 6, 13, 173, 175.
baguionum C. DC., 6, 11, 96, 98.
basilanum C. DC., 124.
bathycarpum C. DC., 85, 89.
begoniaefolium (Blm.) Quis., 2, 5, 6, 9, 189.
betle Linn., 5, 6, 13, 85, 92, 95, 98, 103, 105, 193.
betle Linn. var. densum (Blm.) C. DC., 13, 90.
betle Linn. var. **fenixii** (C. DC.) Quis., 89.
betle Linn. var. **macgregorii** (C. DC.) Quis., 89.
bilineatum Blm., 230.
blancoi Merr., 85.
breviamentum C. DC., 16, 62, 64.
breviamentum C. DC. var. **puberulinervum** Quis., 16, 64.
brevicuspe (Miq.) Merr., 8, 26.
brevistigmum C. DC., 16, 148.
bulusanum C. DC., 176.
cabadbaranum C. DC., 14, 143, 145.
cacuminum C. DC., 10, 68.
cagayanense C. DC., 69, 71.
callosum Ruiz & Pavon, 191.
calvifolium C. DC., 191.
canaliculatum Opiz, 90.
caninum Blm., 5, 14, 120, 121, 123, 130, 135, 136, 141, 143, 145–147, 149, 154.
caninum Blm. var. **basilanum** (C. DC.) Quis., 16, 124.
caninum Blm. var. glabribracteum C. DC., 15, 121, 122.
caninum Blm. var. **hallieri** (C. DC.) Quis., 15, 123, 126.
caninum Blm. var. lanaoense C. DC., 15, 122.
caninum Blm. var. latibracteum C. DC., 15, 126, 142.

Piper—Continued.
caninum Blm. var. **oblongifolium** Quis., 15, 122.
caninum Blm. var. sablanum C. DC., 135, 136.
carnistylum C. DC., 86, 88.
catubigense Merr., 17, 177, 183.
celtidiforme Opiz, 1, 5, 17, 66, 177, 179, 183, 186, 188.
celtidiforme Opiz forma **luzonense** (C. DC.) Quis., 180.
celtidiforme Opiz forma **tubuanense** Quis., 182.
celtidiforme Opiz forma **usteri** (C. DC.) Quis., 181.
celtidiforme Opiz var. **vaginans** Quis., 17, 177, 182.
chaba Blm., 58.
chaba Hunter, 107, 110.
chlorocarpum C. DC., 30, 32.
cilibracteum C. DC., 149.
clemensiae C. DC., 16, 166.
clypeatum Wall., 191, 193.
copelandii C. DC., 2, 62, 64.
cordatilimbum Quis., 5, 16, 141.
corylistachyon C. DC., 5, 177, 179.
corylistachyon C. DC. forma d2 C. DC., 181.
corylistachyon C. DC. forma c C. DC., 181.
corylistachyon C. DC. formæ d and d2 C. DC., 180.
corylistachyon C. DC. var. magnifolia C. DC., 177.
costulatum C. DC., 10, 11, 66, 68, 69, 71.
crassilimbum C. DC., 111.
crassinodum C. DC., 72, 74.
cristatum C. DC., 169, 172.
cumingiana Miq., 27.
cumingianum Miq., 158.
curtifolium C. DC., 5, 10, 76, 77, 79, 80.
dagamiense C. DC., 52.
dagatpanum C. DC., 15, 132.
davaoense C. DC., 16, 160, 161.
decumanum Linn., 5, 8, 42, 47.
delicatum C. DC., 12, 74, 76, 77, 79.
delicatum C. DC. var. glabrum C. DC., 74, 76.
densibaccum C. DC., 14, 131.
densum Blm., 90.
denudatum Opiz, 191.
dipterocarpinum C. DC., 15, 124, 133, 135.
elliptibaccum C. DC., 9, 16, 36, 165, 166.
elmeri Merr., 5, 14, 151.
ensifolium Quis., 8, 119.
eupodum C. DC., 11, 47, 50.
exiguum Blm., 219.
fenixii C. DC., 89.
firmolimbum C. DC., 11, 93.

Piper—Continued.
firmolimbum C. DC. var. **parvilimbum** Quis., 95.
forstenii C. DC., 42.
fragile Benth., 5, 8, 10, 99, 101.
fragile Benth. var. multinerve C. DC., 99, 101.
fuscescentirameum C. DC., 117, 118.
fuscinervum Quis., 9, 83.
gelalae C. DC., 30.
glabrispicum C. DC., 167, 169.
glandulosum Opiz, 20, 22.
grande Ridl., 45.
grande Vahl, 192.
guahamense C. DC., 192.
haenkeanum Opiz, 16, 136, 138, 140.
halconense C. DC., 10, 12, 69, 71, 72, 74, 76, 77, 82.
hallieri C. DC., 123, 124.
hirtirache C. DC., 32, 34.
interruptum Opiz, 4–6, 9, 149, 154, 156, 158, 161, 163, 164, 166, 167, 191.
interruptum Opiz forma c C. DC., 158.
interruptum Opiz var. **cumingianum** (Miq.) Quis., 9, 16, 158.
interruptum Opiz var. herbaceum C. DC., 159, 160.
interruptum Opiz var. **laevirameum** (C. DC.) Quis., 9, 158.
interruptum Opiz var. **loheri** (C. DC.) Quis., 9, 157.
interruptum Opiz var. multiplinerve C. DC., 16, 159, 160.
interruptum Opiz var. subarborescens C. DC., 159, 160.
jagori C. DC., 192.
jayeri, 192.
korthalsii Miq., 5, 6, 16, 169.
korthalsii Miq. var. longibracteum C. DC., 172.
laevifolium Blm., 207.
lageniovarium C. DC., 11, 44, 45.
langlassei C. DC., 13, 90.
lappaceum C. DC., 189.
latum HBK., 192.
laxirameum C. DC., 160, 161.
lessertianum (Miq.) C. DC., 8, 36, 41, 190.
lessertianum (Miq.) C. DC. var. **oblongibaccum** (C. DC.) Quis., 8, 39.
leyteanum C. DC., 45, 47.
lividum C. DC., 111.
loheri C. DC., 157.
loheri C. DC. forma c C. DC., 157.
loheri C. DC. forma multiplinerve C. DC., 159, 160.
longilimbum C. DC., 187, 188.
longipedicellatum Quis., 14, 144.
longistigmum C. DC., 6, 11, 95.
longivaginans C. DC., 5, 11, 12, 72, 74.
longivaginans C. DC. forma b C. DC., 74.
longum Blm., 107, 110.
longum Linn., 88, 193.

Piper—Continued.
longum Rumph., 107, 110.
longum e Philippinis Rumph., 107.
lucbanense C. DC., 111, 113.
luzonense C. DC., 180.
maagnasanum C. DC., 13, 113, 117, 118.
macgregorii C. DC., 89.
magallanesanum C. DC., 72, 74.
maincaw C. DC., 78.
majusculum Blm., 5, 8, 45, 47.
malalaganum C. DC., 15, 137.
malarayatensis C. DC., 90.
malindangense C. DC., 133, 135.
manillanum Miq., 193.
marginatum Jacq., 193.
marivelesanum C. DC., 126, 127, 130.
mearnsii C. DC., 2, 58, 61.
medinillifolium Quis., 11, 29.
melanocaulon Quis., 11, 49.
merrillii C. DC., 8, 9, 52, 54, 56.
merrittii C. DC., 138, 140–142.
merrittii C. DC. var. parvifolium C. DC., 142.
methysticum Linn., 47.
mindorense C. DC., 10, 79.
miniatum Blm., 20, 22.
miniatum Blm. var. hirtellum C. DC., 20, 23.
miquelinum F.-Vill., 58.
mollissimum Blm., 154.
multistigmum C. DC., 9, 163.
myrmecophilum C. DC., 6, 8, 56, 98.
negrosense C. DC., 126, 130.
nigrescens Blm., 74.
nigrum Linn., 5, 167, 192.
nigrum Linn. var. trioicum (Roxb.) C. DC., 16, 167, 169.
obliquum Blco., 177.
oblongibaccum C. DC., 39.
obovatibracteum C. DC., 138, 140, 141.
officinarum C. DC., 107.
oophyllum C. DC., 103, 105.
ovatibaccum C. DC., 12, 80, 81, 83.
palawanum C. DC., 107, 110.
parcipilum C. DC., 127, 130.
parcirameum C. DC., 16, 65.
parong Quis., 12, 105.
parvifolium Blco., 107.
parvispica C. DC., 58.
parvispicum C. DC., 61.
paucinerve C. DC., 15, 147.
pellucida Linn., 218.
peltatum Usteri, 17.
pendulifolium C. DC., 115, 117.
penninerve C. DC., 17, 177, 185.
pergrande C. DC., 45.
perpunctatum C. DC., 120, 121.
petraeum C. DC., 111.
philippinense C. DC., 85, 88.
philippinum Miq., 4, 12, 110, 113, 117.
pilipes C. DC., 9, 25, 30, 32.
pilispicum C. DC., 159.
podandrum C. DC., 66, 68.

Piper—Continued.
polisanum C. DC., 74, 76.
polycladum C. DC., 96, 98.
populifolium Opiz, 58.
potamogetonifolium Opiz, 193.
pseudochavica C. DC., 36.
pseudochavica C. DC. var. angustilimbum C. DC., 39.
psilocarpum C. DC., 117, 118.
puberulinodum C. DC., 85.
pulogense C. DC., 10, 162, 163.
radicans Vahl, 194.
ramosii C. DC., 9, 82, 85, 191.
reinwardtianum C. DC., 180, 181.
retrofractum Vahl, 16, 106, 110.
retrofractum Vahl var. latifolium C. DC., 106, 107.
rhombifolium F.-Vill., 58.
rhombophyllum C. DC., 58.
rhyncholepis C. DC., 27.
rhyncholepis C. DC. var. brevicuspe C. DC., 27.
robinsonii C. DC., 80.
rotundistigmum C. DC., 45, 47.
rotundistigmum C. DC. var. pilosius C. DC., 45, 47.
rubripunctulatum C. DC., 58, 61.
rufinerve Opiz, 194.
sablanum (C. DC.) Quis., 15, 126, 135.
samaranum C. DC., 158.
sarcopodum C. DC., 6, 13, 173, 175.
sarcostylum C. DC., 62, 64.
sarmentosum Roxb., 12, 101.
sarmentosum Roxb. forma b C. DC., 103, 105.
siassiense C. DC., 101, 103.
sibulanum C. DC., 13, 103, 105, 106.
simile Quis., 11, 34.
siriboa Linn., 85.
sorsogonum C. DC., 4, 14, 136, 150, 154.
spathelliferum Quis., 10, 145, 164.
striatum C. DC., 78, 79.
stylosum Miq., 53.
subarborescens C. DC., 159.
subpeltatum Willd., 17.
subprostratum C. DC., 5, 8, 40.
sylvestre Lam., 194.
taumanum C. DC., 194.
tenuipedunculum C. DC., 6, 14, 136.
tenuirameum C. DC., 126, 128, 130.
tomentosa, 5.
tomentosum Vahl var. carnosum Blm., 222.
toppingii C. DC., 11, 30, 32, 34, 39, 192.
trichophlebium Quis., 9, 24.
trioicum Roxb., 167.
unbellatum Linn., 4, 17.
umbellatum Linn. var. glabrum C. DC., 17.
umbellatum Linn. var. subpeltatum (Willd.) C. DC., 8, 17, 19.
urdanetanum C. DC., 10, 32, 34, 36.
usteri C. DC., 181, 182.

Piper—Continued.
varibracteum C. DC., 10, 11, 78, 79, 90.
villilimbum C. DC., 138, 140, 141.
villirache C. DC., 17, 177, 187, 188.
viminale Opiz, 4, 14, 126, 127, 130, 131.
warburgii C. DC., 177, 180.
wenzelii C. DC., 32, 34.
williamsii C. DC., 103, 105.
zamboangae C. DC., 101, 103.
zippelia C. DC., 189.
zollingerianum C. DC., 101.
Plasmodium, 458, 464–467.
praecox, 466.
Platynopoda Westw., 268.
Ploceidæ, 465.
Plumiera acuminata Ait., 477.
Pogápong, 45.
Popillia **furcula** Ohaus, 555.
macronyx Ohaus, 555, 556.
Poruan, 66.
Pothomorphe subpeltata Miq., 17.
Practincola caprata, 464.
Protoopalina, 471.
Protorimarga Alex., 293.
Protozoa parasitic in plants and animals of the Philippine Islands, 451.
Pseudolimnophila, 295.
autumnalis Alex., 508.
luteitarsis Alex., 294, 295.
Pseudoptynx philippinensis Kaup, 551.
Psilistus Stål, 419.
Psittacidæ, 463.
Pugápong, 19.
Pycnonotidæ, 464.
Pycnonotus goiavier, 464.
Pyrotrogon ardens (Temm.), 552.
Python reticulatus, 470.

Q

QUISUMBING, EDUARDO, Philippine Piperaceæ, 1.

R

Rallidæ, 463.
Rana erythraea, 471.
tigerina, 471.
vittigera, 472, 473.
Retortomonas, 475.
orthopterorum, 474, 475.
REYNOLDS, FRANCOIS H. K., JAMES STEVENS SIMMONS, and JOE H. ST. JOHN, The use of tetanus anatoxin in the protection of horses against infection by Chlostridium tetani, 611; Experimental studies of the treatment of surra, 627.
Rhyncholepis brevicuspis Miq., 26, 27.
cumingiana Miq., 27.
haenkeana Miq., 191.
Rhyporobia maderae, 475.
ROXAS, MANUEL L., and MANUEL VILLANO, Studies on the development of the sugar-cane plant in the Philippines, 367.

Ruddy kingfisher, 463.
Rusa, 547.

S

Sabía, 110.
Sabo-manók, 68.
ST. JOHN, JOE H., *see* REYNOLDS, SIMMONS, and ST. JOHN.
Salibútbut, 216.
Salimára, 110.
Salimbañgon, 66.
Salusalong-bata, 74.
Salvadori's swiftlet, 464.
Samaina, 62.
Samát, 89.
Sámat-anák, 157.
Sambañganai, 175.
Samog, 89.
SANTOS, ALFREDO C., Alkaloid from Anona reticulata Linnæus, 561.
SANTOS, IRENE DE and AUGUSTUS P. WEST, Naphthol esters of chaulmoogric acid and chaulmoogryl naphthylamines, 409.
SANTOS, JOSÉ K., Leaf and bark structure of some cinnamon trees with special reference to the Philippine species, 305.
Sapotaceæ, 478.
Sarcocystis, 459.
Sarcops calvus, 465.
Sarcostemon, 7, 169.
Sauodan, 34.
Schizonephros Griff., 173.
SCHÖBL, OTTO, Further experiments concerning immunologic reciprocity between yaws and syphilis, 263; Immunologic reciprocity between syphilis and yaws, 583; The immunologic effect of repeated yaws infections interrupted by specific treatment given in the early stage of initial yaw, 589; The duration of antitreponematous immunity with regard to syphilis in Philippine monkeys, 595; The duration of antitreponematous immunity in Philippine monkeys originally conveyed by immunization with killed yaws vaccine, 599; The immunologic effect of antitreponematous vaccine therapy administered after specific treatment which was given in the early stage of initial local yaws in Philippine monkeys, 603.
Sigbat-ta-pangpang, 220.
SIMMONS, JAMES STEVENS, *see* REYNOLDS, SIMMONS, and ST. JOHN.
Sirium decumanum Rumph., 42.
terrestre Rumph., 101.
Soag-matsíng, 110.
Sobo-manók, 68.
Spirochæta pallida, 435.
pallidula seu pertenuis, 435.
Staphylococcus albus, 614, 620.
Stenonabis Reuter, 419.

Stenopteryx, 537.
Sterna sinensis, 463.
Stibadocera **pumila** Alex., 285.
quadricellula (Brun.), 286.
Stomoxys calcitrans, 629.
Streak-eyed wagtail, 465.
Sturnia sinensis, 465.
Sturnidæ, 465.
Styringomyia, 534.
flava Brun., 533.
mahensis Edw., 534.
sinensis Alex., 509, 533, 534.
taiwanensis Alex., 509, 532, 533.
Súbong-manók, 110, 130.
Subú-manók, 130.
Sugar-cane plant in the Philippines, studies on the development of, 367.
Surra, experimental studies of the treatment of, 627.
Syphilis and yaws, 583.

T

Tabanus striatus, 629.
Tabernaemontana divaricata (Linn.) R. Br., 477.
pandacaqui Poir., 477.
Tabolo, 658.
Tachornis pallidior, 464.
Tagpúan, 85.
Talavera, Florencio, Pearl fisheries of Sulu, 483.
Talon-talón, 29.
Tandanon, 62.
Tandáwon, 47.
Tápi, 172.
Tapis-buyañgan, 71.
Tarsius fraterculus, 458.
Tetanus anatoxin, use of, in the protection of horses against infection by Chlostridium tetani, 611.
Thaumastoptera (Taiwanita) issikiana Alex., 508.
Thevetia peruviana (Pers.) Merr., 477.
Tipula (Tipula) yamata Alex., 507.
Tipulidæ from eastern Asia, 507.
from the Philippines (Diptera), 277.
Tipulinæ, 277, 509.
Tipulodina **cagayanensis** Alex., 279, 280.
joana (Alex.), 280.
luzonica Alex., 278.
succinipennis Alex., 279, 280.
tabuanensis Alex., 277, 278.
tinctipes (Edw.), 280.
Tobayág, 19.
Tonyabayán, 29.
Toxoplasma, 465.
Toybok, 661.
Toxorhina (Ceratocheilus) taiwanicola (Alex.), 508.
Trentepohlia Bigot, 297.
atayal Alex., 300.
bakeri Alex., 298.
banahaoensis Alex., 297.
brevifusa Alex., 297.
Trentepholia—Continued.
duyagi Alex., 297.
holoxantha Alex., 298.
luzonensis Edw., 298.
mcgregori Alex., 298.
pennipes (O. S.), 297.
pictipennis (Bezzi), 298.
poliocephala Alex., 297.
ricardi Alex., 297.
riverai Alex., 297, 300.
saxatilis Alex., 297.
tenera (O. S.), 297.
trentepohlii (Wied.), 298.
(Mongoma) brevifusa Alex., 300.
(Mongoma) duyagi Alex., 298.
(Mongoma) **montina** Alex., 508, 523.
(Mongoma) **riverai** Alex., 299.
(Mongoma) saxatilis Alex., 301.
Treponema pallidum, 433, 443.
pertenue, 429, 433.
Treronidæ, 463.
Tricercomonas, 457.
intestinalis, 456.
Trichodina pediculus, 471.
Trichomastix, 460.
cuniculi, 459.
Trichomonas, 458, 461, 463, 465, 468–470, 472, 473.
buccalis, 457.
caviae, 460.
eberthi, 468.
flagelliphora, 461.
gallinarum, 468.
hominis, 453, 456, 457.
lewisi, 461.
muris, 461.
vaginalis, 457.
Tricyphona arisana Alex., 508.
formosana Alex., 508, 523.
Troglodytella, 456.
Trypanosoma, 465.
evansi, 627–629, 633, 634, 636–638, 641, 643–649.
rotatorium, 470.
Tubóg-manók, 130.
Tugpoai, 39.
Tugpuán, 188.
Turdidæ, 464.

U

Umum, 76.

V

VILLANO, MANUEL, *see* ROXAS and VILLANO.

W

WEST, AUGUSTUS P., *see* SANTOS and WEST.
WESTER, P. J., *see* FRANCISCO and WESTER.
WHERRY, W. B., Cultivation of an acid-fast Bacillus from leprosy, 577.
White-collared kingfisher, 463.

White-shafted tern, 463.
White-throated kingfisher, 463.

X

Xantholæma roseum (Dumont), 551.
Xylocopa Latr., 265, 266.
auripennis Lep., 267.
cantabrita Lep., 267.
dissimilis Lep., 267.
fallax Maidl, 267, 268.
fuliginata Pérez, 266, 267.
fuliginata indecisa Ckll. & LeVeque, 266.
grandiceps (Cam.), 266.
mazarredoi Dusmet, 267.
mcgregori Ckll., 268.
mimetica Ckll., 268.
nigrocærulea Sm., 267.
nobilis Sm., 272.
Xylocopa—Continued.
pictipennis Sm., 268.
sonorina Sm., 267.
thompsoni Ckll., 268.
tranquebarica (F.), 266.
Xylocopid or carpenter bees of the Philippine Islands, 265.
Xylopia etiopica A. Rich., 561.

Y

Yaws, 425, 429.
and syphilis, 263.
Yungipicus validirostris, 464.

Z

Zippelia Quis., 1, 4, 7, 188.
begoniaefolia Blm., 189.
lappacea Benn., 189.

CONTENTS

	Page.
TALAVERA, FLORENCIO. Pearl fisheries of Sulu	483
FAUSTINO, LEOPOLDO A. Notes on Mayon Volcano	501
ALEXANDER, CHARLES P. New or little-known Tipulidæ from eastern Asia (Diptera), VIII	507
FERRIS, G. F. Sixth report upon Diptera pupipara from the Philippine Islands	537
OHAUS, F. VI. Nachtrag zur Kenntnis der philippinischen Ruteliden (Coleoptera, Lamellicornia)	555
SANTOS, ALFREDO C. Alkaloid from Anona reticulata Linnæus	561
GARCIA, ONOFRE. Carbohydrate and serological determinations of the bipolar gas-forming and non-gas-forming organisms isolated from lymph glands of slaughtered cattle	565
WHERRY, W. B. Cultivation of an acid-fast bacillus from leprosy	577
SCHÖBL, OTTO. Immunologic reciprocity between syphilis and yaws	583
SCHÖBL, OTTO. The immunologic effect of repeated yaws infections interrupted by specific treatment given in the early stage of initial yaw	589
SCHÖBL, OTTO. The duration of antitreponematous immunity with regard to syphilis in Philippine monkeys	595
SCHÖBL, OTTO. The duration of antitreponematous immunity in Philippine monkeys originally conveyed by immunization with killed yaws vaccine	599
SCHÖBL, OTTO. The immunologic effect of antitreponematous vaccine therapy administered after specific treatment which was given in the early stage of initial local yaws in Philippine monkeys	603
REYNOLDS, H. K., JAMES STEVENS SIMMONS, and JOE H. ST. JOHN. The use of tetanus anatoxin in the protection of horses against infection by Chlostridium tetani	611
REYNOLDS, H. K., JAMES STEVENS SIMMONS, and JOE H. ST. JOHN. Experimental studies of the treatment of surra	627
FRANCISCO, ANACLETO D., and P. J. WESTER. Analysis and food value of some unusual Philippine fruits	655
INDEX	665

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